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316(b) MONITORING AT NEWTON POWER STATION, 1983-84

Prepared for

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EXECUTIVE SUMMARY

EA Engineering, Science, and Technology conducted a three part (entrainment, impingement and standing crop) study designed to quantify and assess impingement and entrainment losses at Central Illinois Public Service Company's Newton Power Station. The entrainment portion of the study consisted of collecting ichthyoplankton samples at the station's discharge on 39 dates from March through August 1983. Twenty-four hour composite samples were collected twice a week from April through July, and once a week in March and August. These samples yielded a total of 3101 larvae and one egg, distributed among 10 taxa. Gizzard shad (81.2 percent) and sunfishes (18.3 percent) dominated the collections. Entrainment densities were low until the end of May, increased greatly in June, and then steadily declined during the remainder of the sampling period. Gizzard shad dominated the catch in June, while Lepomis sp. dominated for the remainder of the study. Based on the densities recorded it was estimated that during the period April through August 1983, the Newton Power Station entrained 10.8 million gizzard shad larvae, 4.3 million Lepomis sp. larvae, and 0.3 million crappie larvae. Based on the standing crops of these groups estimated to be in the lake, these losses were considered to be negligible.

The impingement portion of the study was conducted for one year from 1 March 1983 through 1 March 1984 and resulted in the collection of 71 twenty-four hour samples. These samples were collected at weekly intervals from May through November and twice weekly from December through April. A total of 379,264 fish (weighing 4,067 kg) distributed among 17 species were collected during the year. The catch was dominated by gizzard shad (92.1 percent numerically), followed by bluegill (5.6 percent), and white crappie (2 percent). Impingement was high in March, April, October, and December through February, moderate in May, September, and November, and negligible during the summer (June through August). For the year, 1,506,338 gizzard shad, 80,191 bluegill, and 27,232 white crappie were estimated to be impinged. Based on the standing crops estimated to be in the lake, these losses were not considered significant, except, possibly for white crappie. However, it was determined that the standing crop of white crappies estimated to be in Newton Lake probably underrepresents the true number.

The standing crop survey consisted of rotenoning four areas (2 coves and 2 non-coves, each about 1.5 acres) of Newton Lake in September 1983. The warm and cool ends of the lake were both sampled. A total of 205,323 fish representing 20 species were collected from the four areas combined. The catch was dominated by gizzard shad (89.7 percent numerically), sunfishes (4.1 percent), and bluegills (4.1 percent). Other common species were longear sunfish, largemouth bass, channel catfish, warmouth, and white crappie. The survey resulted in the first collections of three species (pugnose minnow, tadpole madtom, and Johnny darter) not previously reported from Newton Lake. Most species preferred the cool end of the lake, however, gizzard shad was most abundant in the warm end. Most species preferred the cove areas, with bluegill and white crappie being notable exceptions. Extrapolation of the results from the four areas to the whole lake yielded a lakewide estimate of

46 million fish, of which nearly 40 million were gizzard shad. Estimates for other common species were: bluegill (3.2 million), sunfish spp. (2.1 million), longear sunfish (0.3 million), largemouth bass (0.3 million), channel catfish (0.2 million), white crappie (0.1 million), and warmouth (0.1 million). These eight groups accounted for 99.4 percent of the number and 95.6 percent of the biomass in the lake. Carp, although relatively low in number, contributed 2.8 percent of the biomass. The biomass estimates for Newton Lake compared favorably with the results of other studies. In fact, the total standing crop for Newton Lake (647.4 kg/ha) was higher than any of the other lakes with which it can be compared.

1. INTRODUCTION

On behalf of Central Illinois Public Service (CIPS), EA Engineering, Science, and Technology (EA) conducted a 316(b) study at the Newton Power Station from March 1983 through February 1984. Effects on adult and larval fish were considered through the impingement and entrainment studies, respectively. To determine what impacts impingement and entrainment losses might have on the fish populations of Newton Lake, a standing crop survey was conducted during September 1983.

The objectives of the three studies were:

1. Document the species composition, numbers and biomass of fish impinged at the intake screens for Units 1 and 2.
2. Document the composition and numbers of ichthyoplankton entrained by the station.
3. Determine the temporal changes associated with objectives 1 and 2.
4. Estimate the monthly and total (annual) number of fish, by taxon, impinged and entrained during the study.
5. Obtain quantitative estimates of the standing crop of each fish species in Newton Lake, both for specific habitats (coves and non coves) and for the whole lake.
6. Assess the impact of impingement and entrainment on the Newton Lake fish fauna.

1.1 SITE DESCRIPTION

Newton Lake is a 1789 acre cooling lake located in east-central Illinois. The Newton Power Station, which has two 580 MW (net) units, is located near the north end of the eastern arm of the lake (Figure 1). Cooling water for the plant is drawn from the eastern arm of the lake and the heated water discharged into the extreme northern end of the western arm. This results in a counterclockwise circulation in the lake and the western arm being noticeably warmer than the eastern arm. Thus, the lake can be considered as having a warm end and a cool end.

The Newton Power Station uses an approach channel intake canal with a common intake structure for both units. The intake canal has a maximum approach velocity of 0.6 feet per second under normal operating conditions with all circulating pumps in operation. Total residence time of the cooling water from the time it is withdrawn from the lake until it reenters the lake is 85.9 minutes, of which 76.4 minutes is spent in the discharge flume. Cooling water is provided by four 70,000 gpm circulating water pumps for each unit. When a unit is on-line, two pumps are run continuously. The additional pumps are used during hot weather periods to maximize plant efficiency by minimizing condenser back pressure. The zone of the intake water is not limited and there is no skimmer wall.

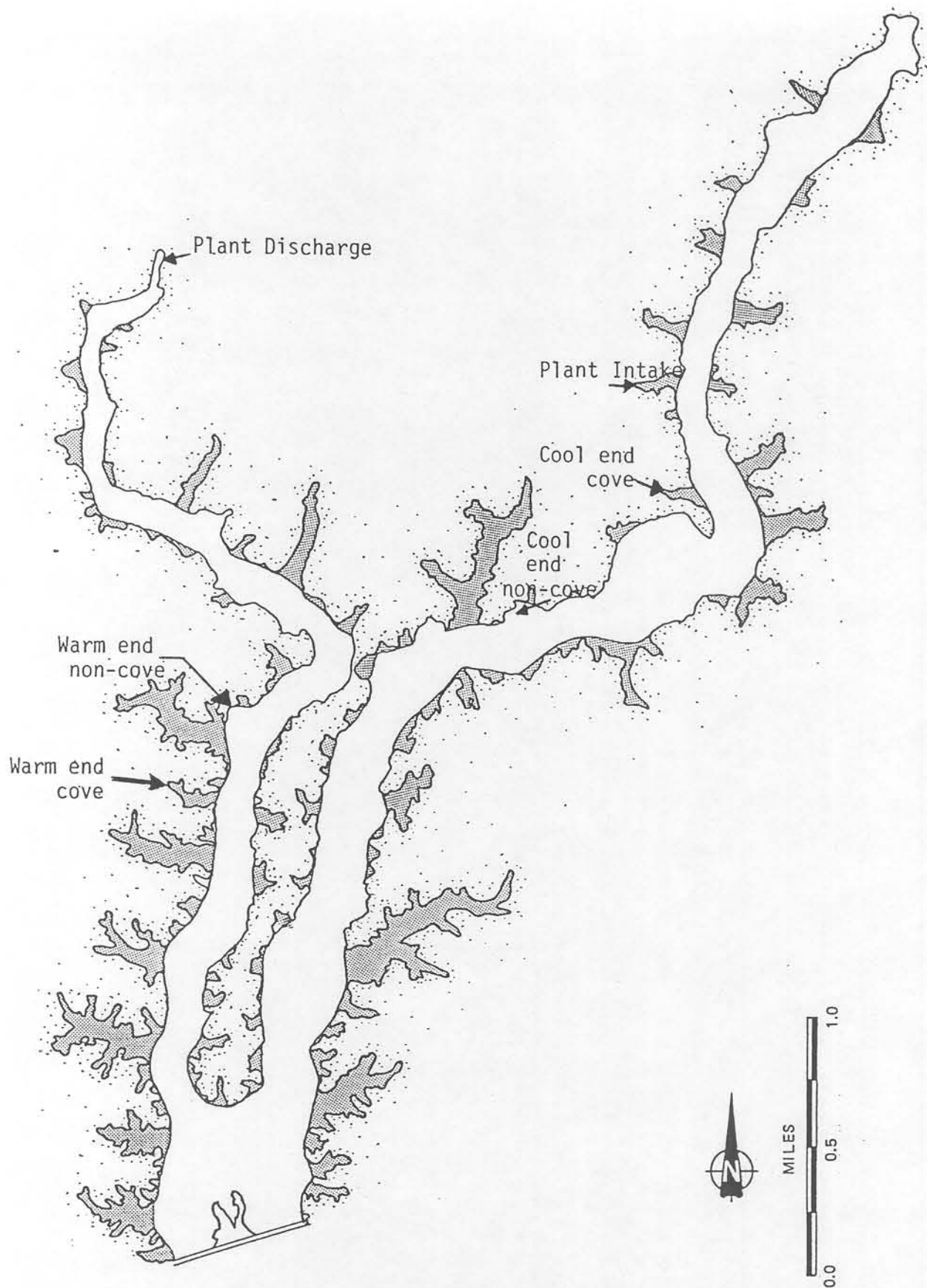


Figure 1. Map of Newton Lake showing the Newton Station intake and discharge areas and the four areas that were rotenoned.

Vertical traveling screens are used in front of each circulating water pump to reduce entrainment of fish. Each screen is covered with 3/8 inch mesh screen wire and is 10 feet wide. The screens are operated at two different speeds. At low speed, one revolution takes approximately 27.2 minutes whereas at high speed one revolution takes approximately 6.8 minutes. Under normal operation, the screens rotate for 20 minutes per day and are backwashed by high pressure water jets (80 psi) once during each eight-hour shift. Fish and debris are washed into a sluiceway which empties into a four by six-foot trap with a .75 inch by .25 inch expanded metal screen. There is no fish bypass system. A deicing line discharges recirculated warm water approximately 13 feet below normal pool during extremely cold weather (i.e., water temperatures <40 F) to enable normal operation of the screens.

2. METHODS

2.1 ENTRAINMENT STUDY

2.1.1 Sample Collection

Sampling for ichthyoplankton passing through the station's cooling water system was conducted on 39 dates from March through August 1983. Samples were collected over a 24-hour period, twice each week from April through July, and once each week in March and August. Samples were collected in the discharge pipe from the station, prior to where it enters the discharge canal. Sampling was conducted in the discharge because the water is thoroughly mixed and ichthyoplankton are uniformly distributed in the water column. Samples were collected with EA's patented, automated abundance sampling system (AUTOSAM) (Figure 2). A quality control check was performed at the time that the AUTOSAM was installed at the Newton Station to ensure that all operational parts were functioning properly. The AUTOSAM was programmed at the time of installation based on the operational sequence described later. The on-site operator was responsible for setting up the AUTOSAM for sampling, safe operation, collection of samples according to Standard Operating Procedures, and the accurate entry of information on the Fisheries Entrainment Abundance Data Sheets.

Prior to the start of each 24-hour entrainment collection, the operator turned on the AUTOSAM and checked all control switches for proper settings. The operator checked the pumps, codends, net, chiller, and preservation system for proper condition. The intake pump was then turned on to start the sampling process. After sufficient head pressure was attained and water began flowing through the system, checks were made at various points along the system to ensure proper performance of all functional parts. The operator attended the AUTOSAM until its proper performance was assured and returned to the AUTOSAM prior to the completion of the 24-hour sampling period to check the system. At the completion of sampling, the eight subsamples (3 hours per subsample) were removed from the AUTOSAM. Accumulated volume and time data for each sample were then recorded on the data sheet. The contents of each sample were transferred from the collection container to a labeled sample jar.

Samples at the Newton Station were collected by sampling within the discharge pipe (approximately 100 feet from where the pipe opens up to form the discharge canal) through a 3-in. intake hose oriented into the current, then pumped into a net in the collection tank where primary concentration of the organisms occurred. Filtered water passed out of the collection tank through a discharge pipe. Flow rate and volume were measured by a Signet inline flowmeter mounted on the pipe which transported water from the sampling pump to the collection tank.

Eight samples, each representing a 3-hour interval, were collected during each 24-hour sampling period. To reduce time between collection and preservation and to ensure high retention of the organisms in the net, each 3-hour sample represented a composite of six collections or cycles of the AUTOSAM, each of 27 minutes duration. At the completion of each cycle, the computer switched off the sampling pump and activated the primary

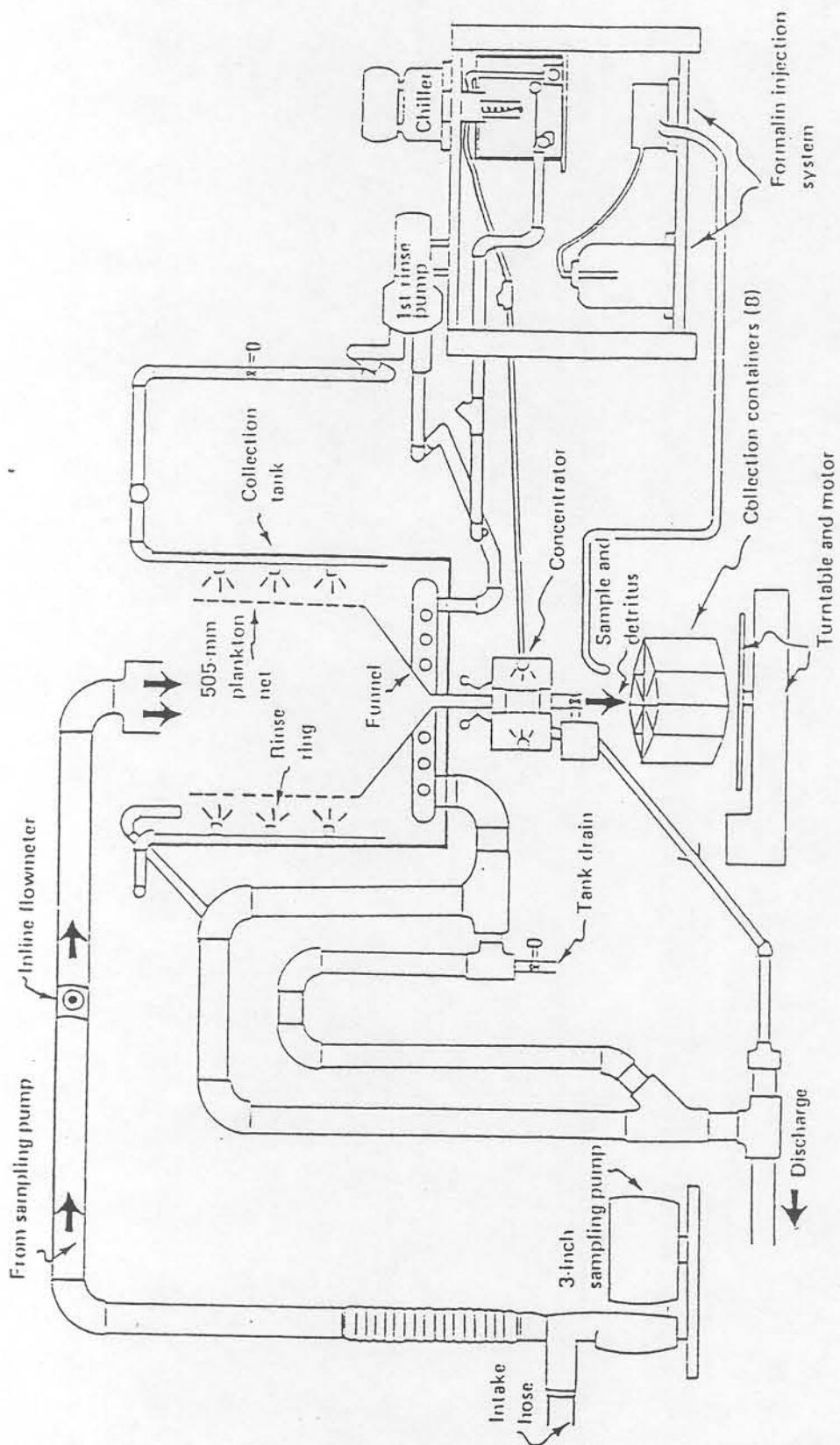


Figure 2 Schematic diagram of the automated abundance sampler (AUTOSAM)

wash pump to wash the sample filtrate into the secondary filtration unit. After a pause for drainage, the computer switched on the secondary wash pump. To retard sample decomposition, feed water from the secondary wash system was chilled to about 4 C by a refrigeration unit. An electric ball valve then opened, allowing the filtrate to be transferred to a sample container. The time between the primary washing and transfer to the container was approximately three minutes. After each 3-hour interval was completed, the computer advanced the sample container turntable one position and activated a metering pump which injected a 10 percent formalin solution into the sample. The sampling sequence began again until eight samples were collected. The system typically operated at flow rates from 700 to 1,300 liters/minute at pump heads up to 6 meters. At the end of each 24-hour period, all samples were transferred from the collection containers to labeled jars for later processing.

2.1.2 Sample Processing

All samples were processed at EA's laboratory in Northbrook, Illinois. Each AUTOSAM sample represented the composite of the eight samples collected during the 24-hour period. Each sample was washed on a screen of not greater than 0.354 mm aperture and then placed in a sorting pan from which all fish eggs and larvae were removed with the aid of an illuminated magnifier. All eggs and larvae were placed in labeled vials containing five percent formalin. Fish larvae were enumerated and identified to the lowest possible taxonomic level using the most recent keys (Auer 1982; Fish 1932; Hogue et. al 1976; May and Gasaway 1967; Meyer 1970; Mansueti & Hardy 1967; Simon 1983), using a stereozoom microscope. State-of-the-art fish egg taxonomy does not allow for most fish eggs to be identified based on morphological and meristic characteristics. However, to aid in possible identifications, fish egg diameters were measured to the nearest 0.1 mm using a calibrated ocular micrometer. The water volume associated with each sample was calculated automatically by the AUTOSAM.

2.1.3 Data Analysis

The volume of water filtered and number of fish eggs and larvae was used to calculate densities (number per cu. m) and percent composition for each larval fish taxon and for fish eggs. Weekly density estimates for each larval taxon were calculated based on sample density values and the volume of water used by the station. An estimate of the total number of larvae entrained during the study period was obtained by summing the weekly estimates.

2.2 IMPINGEMENT STUDY

2.2.1 Sample Collection

Impingement sampling began on 1 March 1983 and continued for one year, through 1 March 1984. Samples were collected at weekly intervals from May through November and twice weekly from December through April. In all, a total of 71 samples were collected.

Impinged fish were collected from the vertical traveling screens of Units 1 and 2 by concentrating screen washings into a collection basket at the intake. To account for any diel differences in impingement rates, each sample was collected during a 24-hour period. Immediately before each sampling period, all screens were rotated and backflushed to remove previously impinged fish and debris, and a clean collection basket was set in place. The screens were then allowed to operate on their normal schedule. At the end of the 24-hour sampling period, the screens were again rotated and backflushed to remove all impinged fish and the collection basket was emptied by plant personnel. The time at the beginning and end of the sampling period was recorded on a log sheet by station personnel and then transferred to field data sheets by EA personnel to document accurately the sampling interval.

2.2.2 Sample Processing

All fish were identified to species. For each species, a maximum of 30 individuals was measured for total length (millimeters). Specimens of smaller species, such as minnows, generally were not measured. When more than 30 individuals of a species were collected, fish were divided into three size groups (small, medium, and large) and a maximum of 10 individuals per size group was measured to reach the minimum total of 30. The remaining individuals within each size group were enumerated but not measured. When the number of gizzard shad, bluegill, or white crappie was exceptionally large, an estimated number was calculated by weighing 100 individuals and obtaining an average weight of these fish. The remaining portion was batched weighed and the number calculated by dividing the batch weight by the average weight. Fish with frayed and missing caudal fins were not measured. All adult sport species that were measured were also weighed (grams). Adults of nonsport fishes, and juveniles and young-of-the-year fish of sport and non-sport species were batched weighed by size group and a composite total weight obtained.

2.2.3 Data Analysis

Daily impingement results were reported as total number, total weight, average weight of each species and size group, and length range for each species (Appendix A). Monthly summaries (Appendix A) and an annual summary of these data were also prepared. Length frequency data for gizzard shad, bluegill, and white crappie was developed for those months in which enough specimens were collected to warrant such analysis.

Estimates of the total number and weight of each fish species impinged at the Newton Station were calculated by month and for the entire study period based on the assumption that the number of fish impinged on non-sampling dates in a month was equal to the average number impinged on the dates that were sampled that month. Therefore monthly estimates were calculated using the following formula:

$$\text{Estimated number or weight impinged per month} = \frac{\sum \text{Number (or weight) per 24 hours}}{\text{number of days in month}} \times \text{number of days in month}$$

The yearly estimate was the sum of the monthly estimates.

2.3 STANDING CROP SURVEY

2.3.1 Sampling Areas

Based on field reconnaissance by CIPS and EA personnel, two cove and two non-cove areas were selected for study. One cove and one non-cove area was established in both the warm and cooler portions of the reservoir. Each area was of sufficient depth to account for the wide range of depths associated with each of the two habitat types. Other considerations, e.g., shoreline configuration, acreage, protection from the wind, etc., were also taken into account in the selection process. The surface acreage (area) of each selected cove was calculated by taking length measurements at selected points within each cove. Each non-cove area encompassed the shallow shoreline and deeper open water areas of the reservoir. The area of each non-cove was calculated based on the area of a semi-circle created by the blocknet. The area of each of the four areas was: cool end cove - 1.33 acres, warm end cove - 1.61 acres, cool end non-cove - 1.35 acres, and warm end non-cove - 1.42 acres.

2.3.2 Sample Collection

Both coves were treated on the first day and two days later both non-coves were treated. Prior to treatment with rotenone, a blocknet, 650 ft in length x 20 ft deep with 0.5 inch bar mesh was deployed across the mouth of each cove. Non-cove areas were enclosed by deploying the blocknet in a semicircle extending outward from the shoreline. To determine the effectiveness of the sampling, seven circular framed nets 10 ft in diameter were randomly deployed along the bottom within each blocked area.

Each of the four areas was treated with rotenone using an amount based on the volume of the blocked-off area and the concentration (dosage rate) required to produce effective results. The average concentration of rotenone applied to the four treatment areas was 1.85 ppm and ranged from 1.5 to 2.2 ppm.

The area near the net was treated first so that fish did not congregate near the net where escape might be possible. The rotenone was then dispersed throughout the remainder of the blocked area. Rotenone was added near the surface and pumped to deeper portions of the water column to ensure dispersal throughout the water column.

Treatment of the two areas sampled each day was staggered by several hours to allow sufficient time for a concentrated collection effort to be made at each area. This typically consisted of three to four boats, each with a two-three person crew retrieving dead and distressed fish from each area for two-three hours after the rotenone was originally applied. After collection, the fish were taken to a central area for processing.

Fish collections were made in each area for two days. Checks for dead fish made at the beginning of the third day revealed that complete removal had been accomplished. Thus, the block nets were removed and the circular frame nets retrieved.

2.3.3 Sample Processing

Fish collected from each of the four treated areas were processed separately. All fish were identified to species and the more common species sorted into three size groups; small, medium and large. Average lengths within these size categories are presented in Section 3 (Tables 10 and 11). For each treated area, individual length and weight measurements were taken of 50 fish per size group of a species. The remaining fish within each size group of a species were either counted and batch weighed or, for abundant species, batch weighed only. Measurements were taken of fish obtained early in the collection process when weights were most representative of actual live weight. Fish collected in the circular frame nets were identified and counted only.

2.3.4 Data Analysis

Separate standing crop estimates were calculated for each treated area. Estimates were developed on the number and biomass (weight) per acre for each species and size group. The total number and biomass for the cove and non-cove habitats within the entire reservoir was estimated using average standing crop values for each habitat. Adjustments to standing crop estimates were made using data acquired from the circular frame nets. A population estimate for the reservoir was made for each species based on the estimated number per acre for each habitat type and the total acreage represented by each habitat type. Planimetry measurements taken from a topographic map of Newton Lake were used to determine total acreage as well as acreage of each habitat type (cove and non-cove, i.e., open water). Of the 1789 total acres calculated for Newton Lake, 506 acres (28.3%) were cove habitat and 1283 acres (71.7%) were non-cove habitat.

Length measurement data was used to plot the length frequency distribution of four major species by habitat type and for the entire reservoir. These data were also used to provide a qualitative assessment of the age class distribution and growth rate of major species in the reservoir.

3. RESULTS AND DISCUSSION

3.1 ENTRAINMENT STUDY

3.1.1 Composition

A total of 10 taxa of ichthyoplankton was collected from Newton Lake during 1983 (Table 1). A total of 3,102 larvae and eggs were collected. The major constituents of the ichthyoplankton catch were the clupeids and centrarchids (Table 2). Gizzard shad composed 81.2 percent of the total catch in 1983, while centrarchids collectively contributed 18.3 percent. Of the centrarchids, 88.9 percent were Lepomis sp. and 8.3 percent were Pomoxis sp. Accurate identification of larval centrarchids was hindered due to the high degree of hybridization among species of Newton Lake. However, given their abundance in the impingement samples and in the standing crop survey (Section 3.3), it seems reasonable to conclude that most of the Lepomis were bluegills. Logperch (Percina caprodes), which have not previously been reported from Newton Lake, were collected on 13 and 27 May (Table A-2). Logperch were of minor significance and contributed 0.3 percent to the total catch. A single viable egg was collected on 4 May and measured 1.6 mm in diameter.

Taxa most frequently collected included Lepomis sp. (21 dates), gizzard shad (20), and Pomoxis (16). Taxa or species collected on only one date during the study included largemouth bass (29 June), and catostominae (8 June). Species sampled with the shortest range of collection dates included carp (3 dates, 8-11 June), and logperch (2 dates).

3.1.2 Temporal Variation

The overall temporal variation in catch is depicted in Figure 3. It can be seen that densities were low until the end of May, increased dramatically in June, followed by a steady decline from the beginning of July through the end of the sampling period. The June peaks were almost entirely attributable to gizzard shad. These data show that gizzard shad, which is the dominant species in Newton Lake, spawns over a fairly limited period; basically from late May through early July, a period of about six weeks.

March/April

No larvae were collected in March and only a single larva (Pomoxis sp.) was entrained during April (on the 30th). Pomoxis sp. were entrained during each month of the study with the April catch comprising only 2.1 percent of the total Pomoxis sp. entrained (Table 3). Density values for April averaged 0.0001 larvae/m³ on the one date when ichthyoplankton was collected.

May

A total of 200 larvae and 1 fish egg distributed among 4 taxa were collected during May (Tables 2 and 3). Gizzard shad composed 90.5 percent of the total entrainment catch for May (Table 2). The remainder of the catch

TABLE 1 SPECIES COMPOSITION, TOTAL NUMBER, DATE OF FIRST COLLECTION, AND DURATION OF ENTRAINMENT OF ICHTHYOPLANKTON FROM NEWTON LAKE, AT THE NEWTON POWER STATION, 1983

<u>Taxa</u>	<u>No.</u>	<u>Date of First Collection</u>	<u>Number of Dates</u>	<u>Range</u>
viable eggs	1	May 4	1	May 4
Gizzard shad	2,520	May 4	20	May 4 - July 20
Carp	5	June 8	3	Jun 8 - Jun 11
Catostominae	1	June 8	1	Jun 8
Lepomis sp.	503	June 8	21	Jun 8 - Aug 30
Bluegill	1	June 20	1	Jun 20
Pomoxis sp.	47	Apr 30	16	Apr 30 - Aug 9
White crappie	2	Jun 29	2	Jun 29 - Jul 20
Largemouth bass	4	Jun 29	1	Jun 29
Centrarchid sp.	9	Jun 22	5	Jun 22 - Aug 16
Logperch	9	May 13	2	May 13 - May 27
TOTAL	3,102			

TABLE 2 PERCENT COMPOSITION EACH MONTH OF ICHTHYOPLANKTON ENTRAINED AT THE NEWTON POWER STATION, 1983

Taxa	No.	Percent Composition Within Months					Total
		Apr	May	Jun	Jul	Aug	
viable eggs	1	--	<0.1	--	--	--	<0.1
Gizzard shad	2,520	--	90.5	94.2	9.6	--	81.2
Carp	5	--	--	0.2	--	--	0.2
Catostominae	1	--	--	<0.1	--	--	<0.1
Lepomis sp.	503	--	--	4.6	84.7	88.6	16.2
Bluegill	1	--	--	--	0.2	--	<0.1
Pomoxis sp.	47	100.0	4.5	0.8	3.5	8.6	1.5
White crappie	2	--	--	<0.1	0.2	--	0.1
Largemouth bass	4	--	--	0.2	--	--	0.1
Centrarchid sp.	9	--	--	<0.1	0.2	2.9	0.3
Logperch	9	--	4.5	--	--	--	0.3
TOTAL	3,102	100	100	100	100	100	100

TABLE 3 PERCENT COMPOSITION (ACROSS MONTHS) OF ICHTHYOPLANKTON ENTRAINED AT THE NEWTON POWER STATION, 1983

Taxa	No.	Percent of Total Catch					Total
		Apr	May	Jun	Jul	Aug	
viable eggs	1	--	100.0	--	--	--	100
Gizzard shad	2,520	--	7.2	91.2	1.6	--	100
Carp	5	--	--	100.0	--	--	100
Catostominae	1	--	--	100.0	--	--	100
Lepomis sp.	503	--	--	22.3	71.6	6.2	100
Bluegill	1	--	--	--	100.0	--	100
Pomoxis sp.	47	2.1	19.1	40.4	31.9	6.4	100
White crappie	2	--	--	50.0	50.0	--	100
Largemouth bass	4	--	--	100.0	--	--	100
centrarchid sp.	9	--	--	11.1	77.8	11.1	100
Logperch	9	--	100.0	--	--	--	100
TOTAL	3,102						

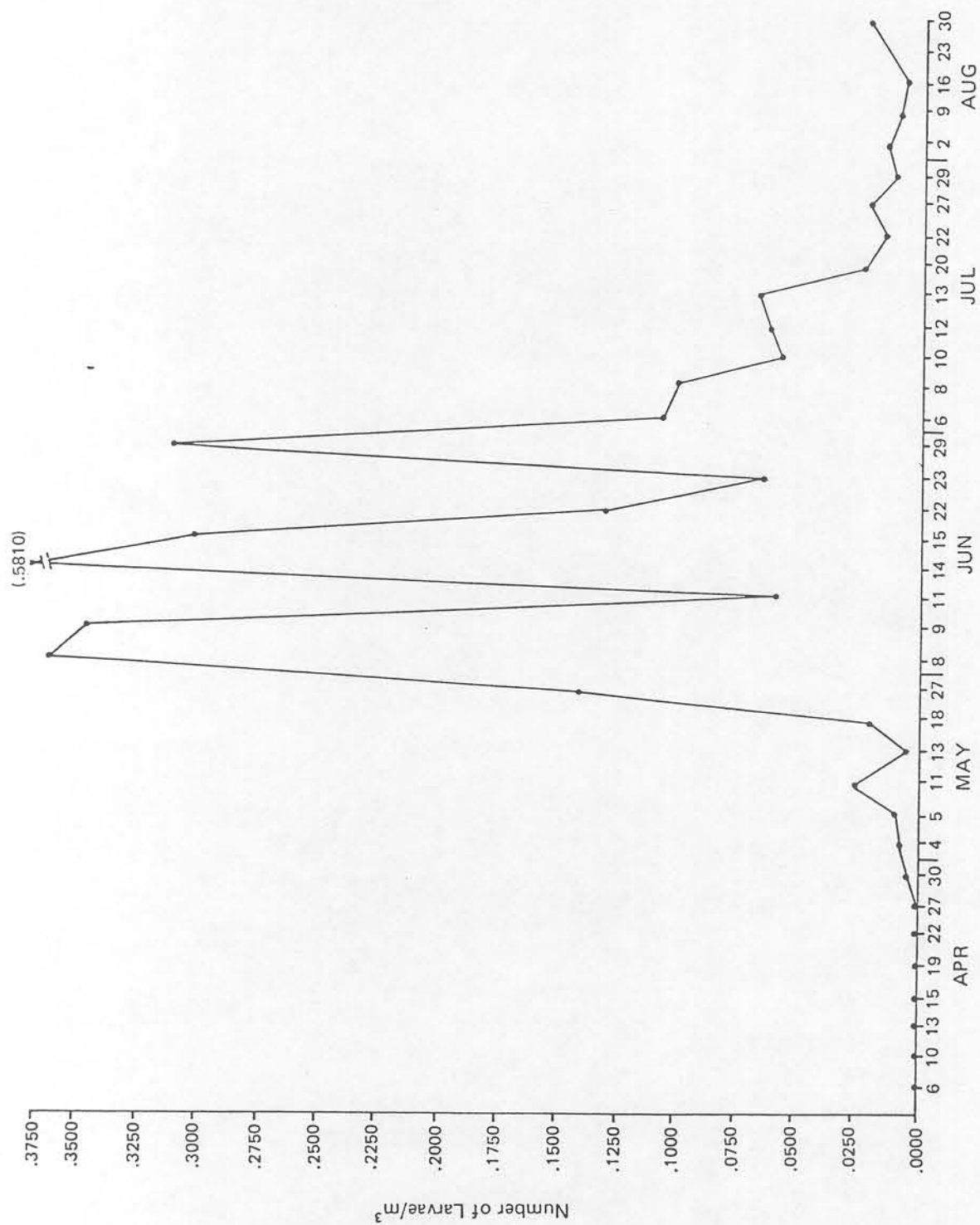


Figure 3 Abundance of ichthyoplankton entrained at the Newton Power Station between 6 April and 30 August 1983.

included Pomoxis sp. and logperch (Table 3). Both contributed 4.5 percent to the entrainment catch for May (Table 2). All logperch were collected in May as was the only egg collected during the study (Table 2). The catch of gizzard shad in May, though the major component of the catch in May, only composed 7.2 percent of the total number of gizzard shad entrained in 1983 (Table 3).

Density values for May averaged 0.0378 larvae (and egg)/m³. Highest May density values were observed on 27 May (0.1301 fish/m³), and lowest values were observed on 13 May (0.0016 fish/m³).

June

The greatest number of ichthyoplankton was entrained during June (Figure 3); a total of 2,439 larval fish in 8 taxa. The June catch accounted for 78.6 percent of all larvae entrained during 1983. Three taxa, carp, catostominae sp., and largemouth bass, were collected exclusively in June (Table 3). However these taxa collectively accounted for less than 0.5 percent of the June catch. The major component of the June entrainment catch was gizzard shad which accounted for 94.2 percent of the June total (Table 2). Lepomis sp., which composed 4.6 percent of the catch, was the only other taxa accounting for more than one percent of the catch in June. The June collections accounted for 91.2 percent of the gizzard shad entrained during 1983 and also accounted for the largest percentage of Pomoxis sp. (40.4 percent) entrained during 1983 (Table 3).

The average density of fish larvae entrained in June was 0.2770/m³. Highest June density values were observed on 14 June (0.5810 fish/m³), which was the peak density for the 1983 study. This peak (and ones on 8 and 9 June) was composed almost entirely (99 percent) of gizzard shad. The lowest June density was observed on 11 June, 0.0598 fish/m³.

July

A total of 425 specimens distributed among 6 taxa were collected during entrainment sampling in July. The majority of the July catch was composed of Lepomis sp. (84.7 percent), with gizzard shad (9.6 percent), and Pomoxis sp. (3.5 percent) composing a smaller percentage (Table 2). The July catch included the largest number of Lepomis sp. (71.6 percent, Table 3) collected during the study.

The average density of ichthyoplankton sampled during entrainment in July was 0.0497 fish/m³. The highest density of ichthyoplankton was collected on 6 July (0.1040 fish/m³), while the lowest density was on 29 July (0.0062 fish/m³).

August

A total of 35 ichthyoplankton distributed among 3 taxa were collected during August entrainment sampling. The major constituent of the August catch was Lepomis sp. (88.6 percent), with Pomoxis sp. (8.6 percent), and centrarchid sp. (2.9 percent) being the only other taxa collected (Table 2).

Average density for August entrainment sampling for 1983 was 0.0090 fish/m³. The highest density for August was recorded on the 30 August (0.0188 fish/m³), while the lowest density (0.0046 fish/m³) was observed on 16 August (Figure 3).

3.1.3 Estimated Entrainment

The very low numbers of carp, catostominae, largemouth bass, and logperch collected indicated that entrainment of these species or taxa was negligible (Table 2). Similarly, the fact 21 additional species (e.g., grass pickerel, channel catfish, walleye) have been reported from the lake (FSE 1982, Price 1983, Section 3.3) but were not found in the entrainment samples indicates that entrainment losses to these species would also be negligible. Therefore, assessment of the impact of larval fish entrainment was restricted to gizzard shad, Pomoxis sp., and Lepomis sp. which accounted for 99.1 percent of the total entrained ichthyoplankton in 1983.

Estimates of the number of entrained larval gizzard shad, Pomoxis sp., and Lepomis sp. were obtained by multiplying the density of these entrained larvae (see Appendix Tables A-1 through A-5 for daily density values) by the mean cooling water flow rate reported by the Newton Station for the corresponding date or period.

A total of 2,520 gizzard shad larvae was collected from Newton Lake entrainment sampling (Table 2). Larval gizzard shad densities were highest from 3 through 10 June and from 13 through 17 June (Table 4). A peak density of 0.5739 gizzard shad larvae/m³ was observed on June 14 (Table A-3). An estimated 10,765,529 gizzard shad larvae were entrained from 3 May through 20 July (Table 4).

A total of 504 Lepomis larvae were collected from Newton Lake. Five species of the genus Lepomis are present in Newton Lake. Bluegill are the most abundant species, but additional species include longear sunfish, green sunfish, warmouth, and orangespotted sunfish. Lepomis larvae were collected from 8 June until the last collection on 30 August. Highest densities of Lepomis larvae were collected 29 June through 20 July with a peak density of 0.1061 Lepomis/m³ on 29 June (Table 4). An estimated 4,338,976 Lepomis larvae were entrained from 3 June through 30 August (Table 4).

A total of 49 Pomoxis larvae were collected during entrainment sampling in Newton Lake. Both black and white crappie are present in Newton Lake however, white crappie are the more abundant of the two. Pomoxis were initially collected 30 April and then sporadically until 9 August. Peak density occurred 6 July with 0.0097 Pomoxis/m³ (Table 4). An estimated 314,445 Pomoxis larvae were entrained from 30 April through 12 August.

3.1.4 Impact Assessment

Assessing or predicting impacts resulting from given levels of larval fish entrainment is difficult because both initial and subsequent natural mortality have to be considered. Initial mortality (i.e., mortality caused by passage through the plant itself) varies widely from nearly 0 to 100 percent depending on the taxa entrained and plant operating conditions (Jinks et al. 1978, EA 1983). Natural mortality due to predation, disease and other factors also varies according to taxa as well as from year to year. In the absence of site-specific data these factors can not be precisely determined. However, they are considered below for the dominant taxa at the Newton Station based on values reported in the literature and on professional judgement.

TABLE 4. SUMMARY OF ESTIMATED ENTRAINMENT OF GIZZARD SHAD, POMOXIS, AND LEPOMIS AT THE NEWTON POWER STATION, 1983

Sampling Period	Cooling Water Used During Period (m ³)	Entrainment Rate (Larvae/m ³)		Estimated Total Larvae Entrained	
		Gizzard shad	Pomoxis	Gizzard shad	Pomoxis
Apr 30 - May 2	2,837,615	--	.0009	--	2,554
May 3-4	1,526,112	.0038	.0010	5,799	1,526
May 5-8	3,052,224	.0047	.0019	14,345	5,799
May 9-11	1,383,039	.0190	.0054	26,278	7,468
May 12-15	1,526,112	.0008	--	1,221	--
May 16-22	2,670,696	.0185	--	49,408	--
May 23 - Jun 2	4,196,808	.1227	--	514,948	--
Jun 3-8	2,368,653	.3504	.0018	829,976	4,263
Jun 9-10	2,289,168	.3307	.0039	757,028	8,928
Jun 11-12	2,646,851	.0567	.0008	150,076	2,117
Jun 13-14	3,831,177	.5739	.0008	2,198,712	3,065
Jun 15-17	6,867,507	.2925	.0016	2,008,745	10,988
Jun 18-22	12,833,753	.1127	--	1,446,364	--
Jun 23-26	6,104,448	.0654	--	399,231	--
Jun 27 - Jul 3	11,445,840	.1857	.0101	2,125,492	115,603
Jul 3-7	9,538,200	.0173	.0097	165,011	92,521
Jul 8-9	3,330,421	.0011	.0043	3,663	14,321
Jul 10-11	4,070,904	.0084	.0010	34,196	4,071
Jul 12	1,907,640	.0010	--	1,908	--
Jul 13-17	11,755,831	.0021	.0010	24,687	11,756
Jul 18-20	8,441,307	.0010	--	8,441	--
Jul 21-24	12,018,132	--	--	--	--
Jul 25-28	11,199,436	--	--	--	--
Jul 29-31	6,358,795	--	--	--	--
Aug 1-5	9,323,591	--	.0020	--	18,647
Aug 6-12	10,817,908	--	.0010	--	10,818
Aug 13-23	22,875,834	--	--	--	--
Aug 24-30	16,850,818	--	--	--	--
TOTAL				10,765,529	314,445
					4,338,976

Gizzard shad

Estimates for initial gizzard shad (clupeid) survival vary widely but an estimate of 25 percent survival is both reasonable and conservative (Jinks et al. 1978, EA 1983). Thus, approximately 8 of the 11 million gizzard shad larvae entrained can be considered lost. No estimate of the total number of larvae in the lake is available. Natural mortality from the larval to juvenile stages (i.e., from entrainment in June to September when the standing crop survey was conducted) would be expected to be high, at least 90 percent, because gizzard shad is the dominant forage species in the lake. Assuming a natural mortality of 90 percent the loss of gizzard shad that would have become juveniles amounts to approximately one million fish. This amount is negligible compared to the 38 million juvenile (small) shad that were estimated to be in the lake during the September standing crop survey (see Table 15, Section 3.3).

Lepomis spp.

No data are available in the literature regarding the survival that can be expected for entrained Lepomis. However, given their high temperature tolerance (Talmage and Opresko 1981), and their general tolerance to handling an estimate of 50 percent survival seems reasonable, and is probably conservative. Thus, the number of larvae initially removed from the population is about 2.2 million. Assuming natural mortality between June and September of 80 percent, this figure is reduced to about 0.4 million. This compares to an estimated lake-wide population of YOY Lepomis in September of 3.6 million. Thus, the number of YOY Lepomis in Newton Lake in September was approximately 11 percent lower than if none had been entrained. This level of removal should not be harmful given the high Lepomis populations in the Lake and their stunted condition. Other investigators have commented previously on the stunted size and poor condition of bluegills in Newton Lake. For example, ESE (1982) noted that bluegills were abundant in the lake in 1982 but reported that they lacked sufficient size to be "consistently desirable sport species". The IDOC reported similar results during fish surveys in May and October 1983. In May, they found that only 6 of 158 bluegills were >7 inches (IDOC 1983). In October, they collected no bluegills (out of 237 individuals) over 7 inches and reported that bluegills "were in poor condition" and that "the quality of the bluegill population continued to be poor with few fish achieving quality size" (IDOC 1984). In fact, IDOC considers the bluegills of Newton Lake to be forage not sport species (Price 1983). The poor quality of bluegills in Newton Lake is discussed further in Sections 3.2.3 and 3.3.

Pomoxis sp.

No data are available in the literature regarding expected survival rates for this taxa. If, as was done for bluegills, 50 percent survival is assumed, an estimated 157,000 Pomoxis larvae would be removed from the population. Most of the larvae entrained were 4-6 mm, only a few days old. Hackney and Webb (1978) reported that Pomoxis numbers in a Tennessee reservoir were reduced naturally by 98.4 percent between days 4 and 45 post hatch. If one assumes that a 99 percent reduction would have occurred naturally in Newton Lake in the 90 day period between the entrainment and standing crop surveys, a total of only about 1,600 Pomoxis juveniles were lost. This represents about 2 percent of the small Pomoxis estimated to be in the lake (see Table 15, Section 3.3). Such a loss would not be consequential.

In summary, once entrainment losses are adjusted for survival during passage through the plant and particularly for subsequent natural mortality, the entrainment losses caused by the Newton Station become small compared to the available standing crops of the dominant taxa.

3.2 IMPINGEMENT STUDY

3.2.1 Composition

The year-long impingement study resulted in the collection of 379,264 fish weighing 4,067 kg representing 17 species (Table 5). Gizzard shad was the dominant species (92.1 percent numerically) followed by bluegill (5.6 percent), and white crappie (2 percent). Together, these three species composed 99.7 percent of the impingement catch. These three species plus the other Pomoxis and Lepomis species listed in Table 5 accounted for 99.8 percent of the total catch. Other species which were reasonably common (>0.1 percent) were channel catfish (0.1 percent numerically, 0.2 percent by weight), longear sunfish (0.1 percent both numerically and by weight), largemouth bass (0.5 percent by weight), and bowfin (0.5 percent by weight). Data on the average length of each impinged species are provided in Appendix A.

The results of the impingement survey agree very well with those from the entrainment study (Section 3.1) and the standing crop survey (Section 3.3). All three efforts showed that gizzard shad dominate Newton Lake with the estimated percent relative abundance ranging from 81.2 percent (entrainment) to 92.1 percent (impingement). Similarly, all three studies show Lepomis spp. to be the second most abundant group in the lake with estimates ranging from 5.6 percent (impingement) to 16.2 percent (entrainment). The percent abundance estimated for gizzard shad, Lepomis spp., and Pomoxis spp. combined is remarkably similar among the three studies: impingement 99.8 percent, entrainment 99.1 percent, and standing crop 98.3 percent. Clearly, these are the dominant taxa in the lake.

Of the 17 species collected during the impingement study, all except for black bullhead were reported during the September 1983 standing crop survey (see Section 3.3). Sixteen other species have been reported from Newton Lake (ESE 1982, IDOC 1983, Section 3.3), but all are rare or uncommon so their absence in the impingement samples is not surprising.

3.2.2 Temporal Considerations

Strong monthly and seasonal patterns in the impingement catch were noticeable, both for individual species and for total catch (Figures 4-6). Gizzard shad impingement was high in March, April, October, and December through February, negligible during the summer (May through August) and moderate in September and November (Figure 4). It is unclear whether gizzard shad are attracted to the intake area during cool/cold water periods or whether the plant is impinging shad that died or were distressed by cold water. Attraction of the shad due to heating of the intake water during recirculation may account for some of the increased impingement during cold water periods. However, recirculation was only employed during a portion of the period when impingement rates were high. Figure 4 also shows that except in March and April, the gizzard shad impingement catch was composed almost entirely of small (2-6 g) gizzard shad. In March and April, a considerable number of medium sized (20-30 g) gizzard shad were also impinged.

TABLE 5 TOTAL NUMBER, WEIGHT AND PERCENT COMPOSITION OF ALL FISH TAXA COLLECTED DURING THE NEWTON POWER STATION IMPINGEMENT STUDY MARCH 1983 THROUGH FEBRUARY 1984.

SPECIES NAME	SIZE GROUP	NUMBER	% OF TOTAL #	TOTAL WEIGHT(g)	% OF TOTAL WEIGHT	AVERAGE WEIGHT
Gizzard shad	small	276,682	73.0	1,740,198	42.8	6.3
	medium	71,952	19.0	1,709,092	42.0	23.8
	large	639	0.2	51,508	1.3	80.6
	total	349,273	92.1	3,500,798	86.1	10.0
Bluegill	small	7,882	2.1	27,394.5	0.7	3.5
	medium	12,788	3.4	277,102	6.8	21.7
	large	715	0.2	42,238.5	1.0	59.1
	total	21,385	5.6	346,735	8.5	16.2
White crappie	small	6,831	1.8	52,973	1.3	7.8
	medium	477	0.1	29,121	0.7	61.2
	large	270	0.1	69,098	1.7	255.9
	total	7,578	2.0	151,192	3.7	20.0
Channel catfish	NA ^a	360	0.1	8,535.5 ^b	0.2	23.7
Longear sunfish	NA	223	0.1	5,057.5	0.1	22.7
Largemouth bass	NA	125	<0.1	19,252	0.5	154.0
Green sunfish	NA	122	<0.1	1,606.5	<0.1	13.2
Black bullhead	NA	75	<0.1	5,961.5	0.1	79.5
Golden shiner	NA	40	<0.1	622	<0.1	15.6
Black crappie	NA	35	<0.1	2,446	0.1	69.9
Warmouth	NA	20	<0.1	1,347.5 ^b	<0.1	67.4
Sunfish hybrid	NA	9	<0.1	139	<0.1	15.4
Carp	NA	7	<0.1	1,499	<0.1	214.1
Tadpole madtom	NA	7	<0.1	21 ^c	<0.1	3.0
Bowfin	NA	6	<0.1	20,945	0.5	3,490.8
Yellow bullhead	NA	4	<0.1	394	<0.1	98.5
Bluntnose minnow	NA	1	<0.1	5	<0.1	5.0
Orangespotted sunfish	NA	1	<0.1	1	<0.1	1.0
TOTAL		' 379,264		4,066,557.5		

^aNA - Not Applicable; all fish individually processed.

^b Partial remains of 1 specimen precluded length and weight measurements for all individuals.

^c Partial remains of 2 specimens precluded length and weight measurements for all individuals.

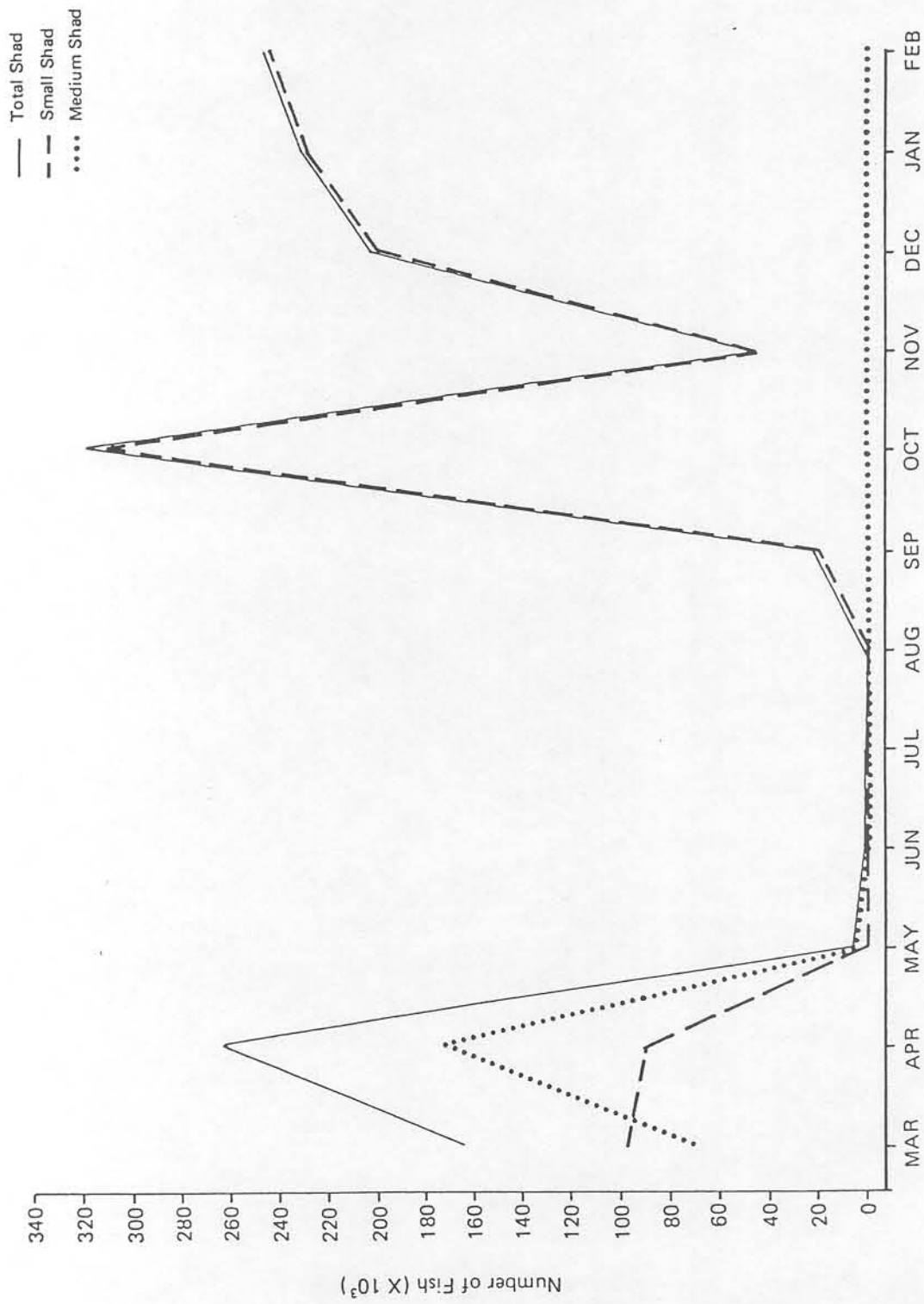


Figure 4 Monthly gizzard shad impingement at the Newton Power Station, March 1983 — February 1984.

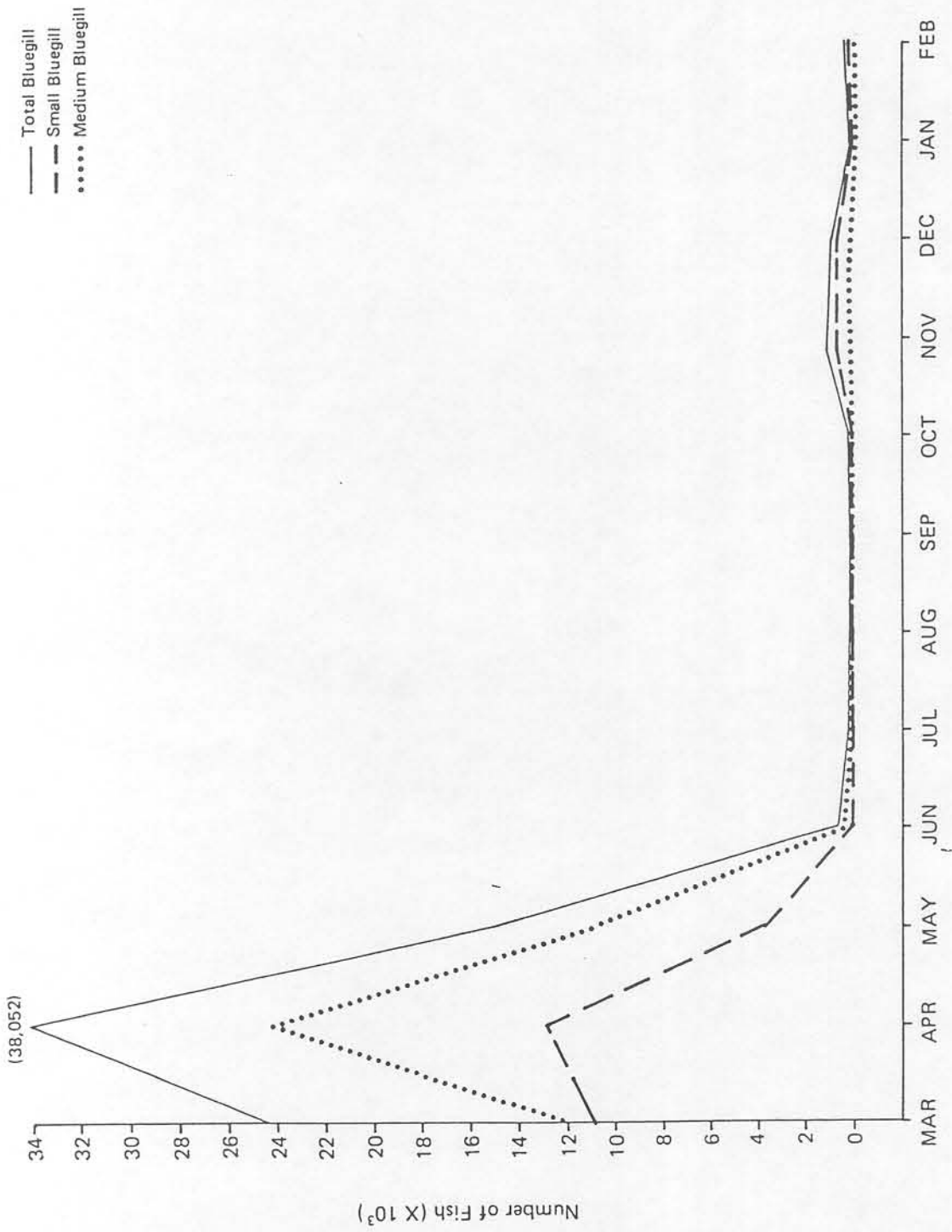


Figure 5 Monthly bluegill impingement at the Newton Power Station, March 1983 — February 1984.

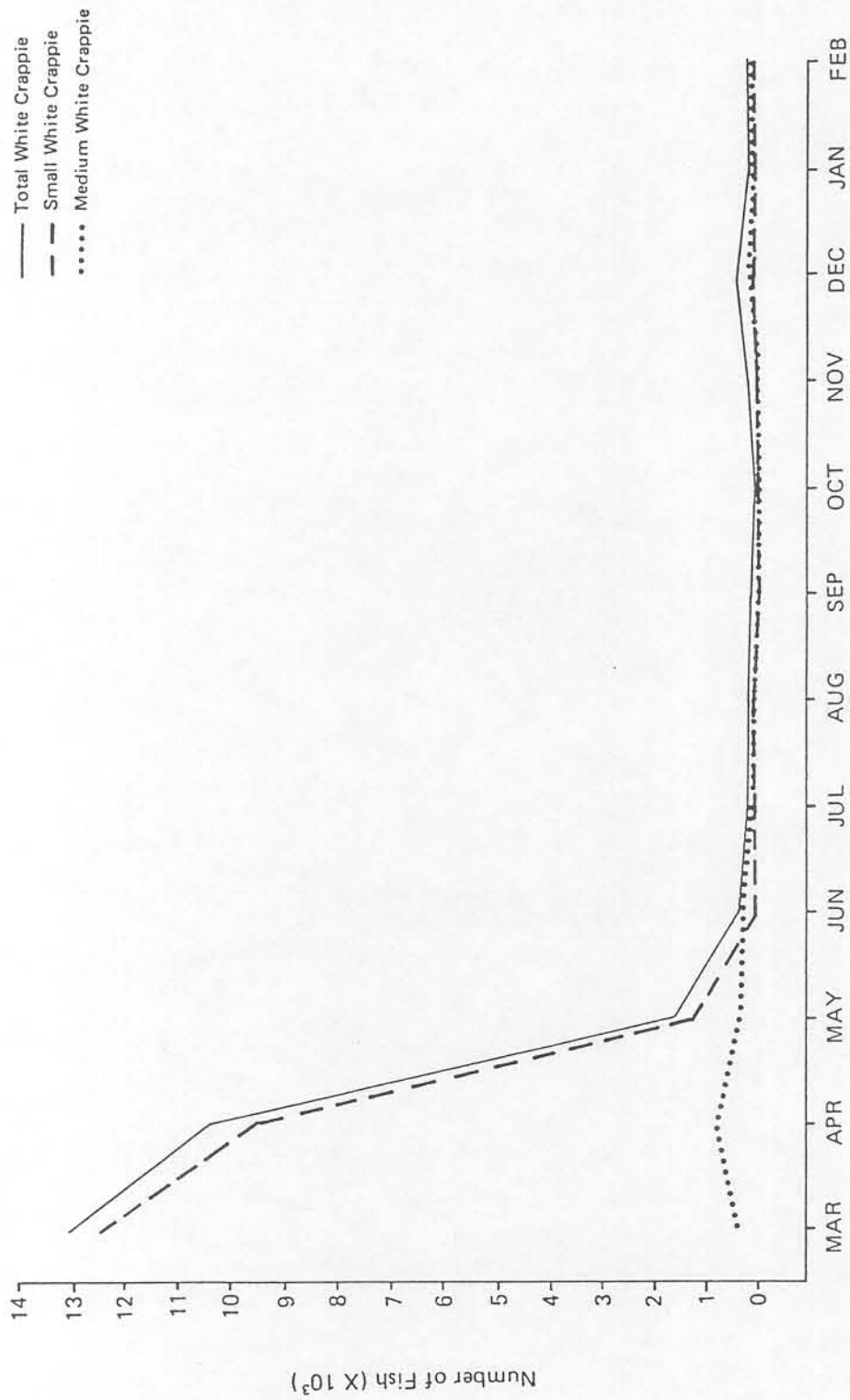


Figure 6 Monthly white crappie impingement at the Newton Power Station, March 1983 – February 1984.

Bluegill impingement was high (15,000-38,000 per month) during March through May and low during the remainder of the year (Figure 5). Figure 5 also shows that neither small nor medium sized bluegills consistently dominated the catch. Whereas the gizzard shad impingement rates were cyclic and clearly associated with low water temperatures, the cause of the high bluegill impingement rates during March through May is unclear. The fact that rates did not increase in the November through February period demonstrates that water temperature alone does not dictate bluegill impingement rates. Given the low impingement rate in February 1984, it seems unlikely that impingement levels in March of 1984 would approach those recorded during March 1983. However, it is not possible to determine whether high rates of impingement of bluegills are a regular occurrence in Newton Lake during the spring or whether the high levels recorded during the spring of 1983 were atypical.

The impingement pattern for white crappie (Figure 6) was quite similar to that seen for bluegill (Figure 5). The main differences were that (1) high numbers of white crappie were impinged only during March and April and (2) medium sized crappies were never impinged in high numbers (as were medium sized bluegills).

The relatively small number of individuals of the other species impinged precludes a detailed discussion of their temporal impingement pattern. However, it was noticed that the impingement rates for longear sunfish and green sunfish were highest in March and April, as was the case for their close relative, the bluegill. Also, it was noted that impingement rates of all species (not just gizzard shad, bluegill, and white crappie) were very low during the summer.

3.2.3 Estimated Impingement

Limitations of the Data

The ultimate purpose of any impingement study is to determine whether the number of fish impinged is such that the resource is being adversely impacted. Such a determination is difficult because of the difficulty in accurately estimating the size of the resource and the natural (normal) year to year variability that is typical of fish populations. Also, pelagic (open water) species may be underestimated because they spend a significant portion of their time in water too deep to be sampled effectively.

The monthly impingement estimates shown in Tables 6 and 7 were developed using the assumption that impingement rates on non-sampling dates in a given month were equivalent to those on the dates that month when sampling did occur (see Section 2). Murarka et al. (1978) report that sampling intensities of 20-40 percent allow impingement numbers to be estimated with a high degree of precision. Since sampling took place on approximately 20 percent of the days (71/365) in the year-long study period, the accuracy of the monthly and annual estimates would be expected to be high. However, it is not possible to determine whether impingement rates during this study period were typical of other years.

TABLE 6 SUMMARY OF MONTHLY IMPINGEMENT (BY NUMBER) AT THE NEWTON POWER STATION, MARCH 1983 - FEBRUARY 1984.

Species Name	Size	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Total
Gizzard shad	small	96,808	89,700	50	37	78	6	20,633	321,121	47,453	203,700	231,966	247,327	1,258,8
	medium	65,460	171,535	6,956	173	-	-	75	16	105	639	303	34	245,2
	large	1,469	559	99	30	-	-	-	-	7	4	38	47	2,2
	total	163,737	261,794	7,105	240	78	6	20,708	321,137	47,565	204,343	232,307	247,408	1,506,3
Bluegill	small	10,943	12,817	3,726	-	31	-	-	39	607	594	28	81	28,0
	medium	11,982	24,409	11,061	420	31	37	157	62	240	124	17	133	48,6
	large	1,276	826	205	23	8	-	90	23	30	62	10	99	2,6
	total	24,201	38,052	14,992	443	70	37	247	125	877	780	55	313	80,1
White crappie	small	12,570	9,567	1,240	7	155	217	23	15	105	102	17	4	24,0
	medium	365	796	304	190	31	6	67	8	15	53	62	34	1,9
	large	193	60	112	170	31	13	60	31	53	284	96	176	1,2
	total	13,128	10,423	1,656	367	217	236	150	54	173	439	175	214	27,2
Channel catfish	NA ^a	96	167	56	7	16	124	60	15	315	780	83	73	1,7
Longear sunfish	NA	248	293	260	7	-	-	-	-	23	40	3	30	9
Largemouth bass	NA	93	87	25	7	-	6	23	31	75	182	21	9	5
Green sunfish	NA	145	147	87	-	-	-	-	31	60	31	10	-	5
Black bullhead	NA	93	53	25	-	31	-	7	8	7	58	7	26	3
Golden shiner	NA	52	67	19	-	-	-	-	-	-	9	-	-	1
Black crappie	NA	24	50	19	60	8	-	-	8	-	-	-	-	1
Wormmouth	NA	17	23	12	7	-	-	-	8	7	-	3	4	-
Sunfish hybrid	NA	3	-	6	-	-	-	7	23	23	-	-	-	-
Carp	NA	3	-	6	-	-	-	-	-	-	13	-	9	-
Tadpole madtom	NA	10	7	12	-	-	-	-	-	-	-	-	-	-
Bowfin	NA	14	-	-	-	-	-	-	8	-	4	-	-	-
Yellow bullhead	NA	-	-	-	7	-	-	-	-	-	4	3	4	-
Bluntnose minnow	NA	3	-	-	-	-	-	-	-	-	-	-	-	-
Orangespotted sunfish	NA	-	-	-	-	-	-	7	-	-	-	-	-	-
TOTAL		201,867	311,163	24,280	1,145	420	409	21,209	321,448	49,125	206,687	232,667	248,090	1,618,4

^aNA - Not Applicable, all fish processed individually

TABLE 7 SUMMARY OF MONTHLY IMPINGEMENT (BY WEIGHT, kg) AT THE NEWTON POWER STATION, MARCH 1983 - FEBRUARY 1984.

Species Name	Size	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Total
Gizzard shad	small	568.4	511.2	0.3	<0.1	0.1	<0.1	67.1	2,052.6	329.4	1,335.8	1,369.4	1,483.9	7,918.2
	medium	1,826.2	3,804.7	164.7	1.1	-	-	3.3	0.5	4.2	20.2	9.8	2.1	5,836.8
	large	98.7	59.7	8.4	1.6	-	-	-	-	0.9	0.8	5.1	6.6	181.8
	total	2,493.3	4,375.6	173.4	2.7	0.1	<0.1	70.4	2,053.1	334.5	1,356.8	1,584.3	1,492.6	13,936.8
Bluegill	small	30.2	40.9	19.6	-	0.5	-	-	0.1	5.5	8.1	0.6	1.5	107.0
	medium	266.8	547.1	190.0	5.4	0.7	1.5	4.5	1.6	5.6	3.6	0.6	4.3	1,031.7
	large	73.3	48.2	16.5	1.7	0.7	-	6.2	1.1	1.1	3.9	0.6	5.7	159.0
	total	370.3	636.2	226.1	7.1	1.9	1.5	10.7	2.8	12.2	15.6	1.8	11.5	1,297.7
White crappie	small	96.4	74.7	12.7	<0.1	0.3	0.5	<0.1	0.1	0.8	0.8	0.2	0.1	186.6
	medium	22.2	46.0	17.8	9.6	1.1	0.2	6.6	0.8	0.5	4.3	5.0	2.7	116.8
	large	31.9	14.5	14.9	9.7	6.1	3.2	19.3	10.6	8.4	96.0	32.0	63.6	310.2
	total	150.5	135.2	45.4	19.3	7.5	3.9	25.9	11.5	9.7	101.1	37.2	66.4	613.6
Channel catfish	NA ^a	2.1	2.1	0.4	-	3.6	4.9	1.0	2.1	10.0	15.6	1.4	1.4	44.6
Longear sunfish	NA	5.5	6.6	5.1	0.3	-	-	-	-	0.8	1.4	0.1	0.8	20.6
Largemouth bass	NA	12.0	11.4	0.4	1.8	-	2.8	16.7	7.1	2.5	22.8	10.3	0.1	87.9
Green sunfish	NA	2.5	1.6	0.9	-	-	-	-	0.2	0.4	0.3	0.3	-	6.2
Black bullhead	NA	2.3	3.7	1.5	-	5.6	-	<0.1	1.0	0.1	9.3	0.2	3.9	27.6
Golden shiner	NA	1.0	0.8	0.4	-	-	-	-	-	-	0.1	-	-	2.3
Black crappie	NA	1.9	4.4	1.1	2.9	<0.1	-	-	<0.1	-	-	-	-	10.3
Warmouth	NA	0.6	1.0	0.4	-	-	-	-	0.1	0.3	<0.1	2.1	0.6	5.1
Sunfish hybrid	NA	<0.1	-	<0.1	-	-	-	0.2	0.1	0.6	-	-	-	0.9
Carp	NA	0.4	-	0.6	-	-	-	-	-	-	2.6	-	3.0	6.6
Tadpole madtom	NA	<0.1	<0.1	-	-	-	-	-	-	-	-	-	-	<0.1
Bowfin	NA	56.9	-	-	-	-	-	-	14.5	-	11.2	-	-	82.6
Yellow bullhead	NA	-	-	-	0.2	-	-	-	-	-	0.7	0.5	0.3	1.7
Bluntnose minnow	NA	<0.1	-	-	-	-	-	-	-	-	-	-	-	<0.1
Orangespotted sunfish	NA	-	-	-	-	-	-	<0.1	-	-	-	-	-	0.1
TOTAL		3,099.3	5,178.6	455.7	34.3	18.7	13.1	124.9	2,092.5	371.1	1,537.5	1,638.2	1,580.6	16,144.1

^aNA - Not Applicable, all fish processed individually

As judged by the large number of fish captured and the high productivity estimates relative to other lakes (see Section 3.3), the standing crop survey conducted in September of 1983 appeared to be very effective. However, by necessity only a small portion of the lake was sampled so considerable extrapolation was necessary. Although it is not possible to say for sure whether the standing crop in September of 1983 was normal (for that time of year) or atypically high or low, catch per unit effort data reported by the IDOC (IDOC 1982, 1983, 1984) suggests that the populations of most of the more common species in the lake were similar in 1982 and 1983, with the exception of gizzard shad which was caught much more frequently in 1983 than in 1982.

Impact Assessment

Even in the context of the above limitations, it is apparent that the populations of most species in Newton Lake would not be affected by the impingement losses shown in Tables 6 and 7. Impingement losses generally constituted less than one percent of the estimated population of the various non-dominant species in Newton Lake (Table 8). The only notable exception was black crappie for which impingement losses apparently were equivalent to 4.7 percent of the population. However, the population estimate for black crappie may be low because rotenone surveys typically underestimate crappie populations (Hayne et al. 1968, Davies and Shelton 1983).

An estimated 1,506,338 gizzard shad were impinged during the one year study (Table 6). This constitutes 3.8 percent (by number) of the estimated population (Table 8). Given the fecundity of this species and its high absolute abundance (see Section 3.3), no long term impacts on gizzard shad populations are predicted.

An estimated 80,191 bluegill weighing 1298 kg were impinged during the study period (Tables 6 and 7). This represents 2.5 and 5.0 percent of the estimated population, by number and weight, respectively (Table 8). During the standing crop survey, a considerable number of sunfish could not be identified to species either because of their small size or advanced state of decay. Assuming that 86 percent of these unidentified sunfish were bluegills (the percentage that bluegills composed of *Lepomis* that could be identified), the percentages which the impingement losses represented are reduced to 1.6 percent by number and 4.1 percent by weight. Given the large bluegill population in Newton Lake, this amount of removal does not seem excessive. In fact, length-frequency data collected during the impingement study and particularly during the standing crop survey indicate that *Lepomis* species in general and bluegill in particular are stunted in Newton Lake. The standing crop survey reported that 99.9 percent of the bluegills were <150 mm (6"), too small to be sought by most anglers (Section 3.3). Moreover, no bluegills >160 mm were collected. Recent IDOC studies (IDOC 1983, 1984) confirm the stunted condition of bluegills in Newton Lake (also see Section 3.1.4). Similarly, fishermen encountered during the standing crop survey confirmed that few "keeper" bluegills were present. Therefore it appears that the bluegill population in Newton Lake already exceeds the available forage base. Finally, it

TABLE 8. PERCENT THAT IMPINGEMENT LOSSES MAKE UP OF THE TOTAL NUMBER (OR WEIGHT) OF FISH ESTIMATED TO BE IN NEWTON LAKE BASED ON A SEPTEMBER 1983 STANDING CROP SURVEY.

Species	Size	Percent	
		by No.	by Wt.
Gizzard shad	small	3.3	3.0
	medium	18.5	9.3
	large	3.6	2.4
	total	3.8	4.2
Bluegill	small	1.6	3.4
	medium	4.6	7.9
	large	0.7	1.6
	total	2.5(1.6)*	5.0(4.1)*
White crappie	small	29.2	86.0
	medium	7.6	7.7
	large	4.0	5.2
	total	20.0	8.0
Channel catfish		1.0	0.2
Longear sunfish		0.3	0.5
Largemouth bass		0.2	0.2
Green sunfish		0.9	0.9
Black bullhead		NA	NA
Golden shiner		0.8	1.6
Black crappie		4.7	3.6
Warmouth		0.1	0.1
Sunfish hybrid		<0.1	<0.1
Carp		0.2	0.1
Tadpole madtom		0.1	<0.1
Bowfin		1.5	2.1
Yellow bullhead		0.3	1.1
Bluntnose minnow		<0.1	<0.1
Orangespotted sunfish		<0.1	<0.1

* The numbers in parenthesis were calculated by including 86 percent of sunfish spp. in the bluegill count.

should be noted that >96 percent of the bluegills impinged during the study were impinged in only three months, March through May. It is unknown whether this high level of impingement is typical or whether it might be much lower during this period in other years.

An estimated 27,232 white crappie weighing 614 kg were impinged during the study period (Table 6). These values represent 20 percent of the number and 8 percent of the biomass of white crappie estimated to be in Newton Lake. If the impingement and standing crop estimates are accurate, these percentages suggest that plant impingement may adversely affect white crappie populations in Newton Lake. However, as discussed below there are reasons to believe that the actual population of white crappies in Newton Lake is larger than was estimated during the standing crop survey. The group that appears to be affected most significantly is small crappies, for which 29.2 percent were estimated to be impinged. The standing crop survey estimated that there were 135,964 white crappie in Newton Lake in September of 1983, of which 82,294 were classified as small (Section 3.3). However, it seems very unlikely that the Newton Station would or could impinge 29 percent of the small crappies in the lake. Four possibilities could explain this unlikely set of circumstances. First, 92 percent of the small crappies estimated to be impinged were impinged in only two months, March and April (Table 6). As suggested previously, this level of impingement may be atypically high. Second, there may have been a very good hatch of white crappies in the spring of 1982, which resulted in there being a very large year class of small crappie available to be impinged during March and April of 1983. Third, the hatch of white crappie in 1983 may have been very poor, thereby inflating the percentage impinged. With regard to the third and fourth points, it is well known that crappie abundance is cyclical, with strong year classes typically occurring at 3 to 5 year intervals (Swingle and Swingle 1968). Fourth, the number of small white crappies estimated to be in the lake may have been low. The fact that no small black crappie were captured during the standing crop survey is consistent with the third and fourth possibilities.

Based on the literature, the fourth point (underestimation of the true number of white crappies in the lake) seems quite likely. This phenomenon is related to the behavior of white crappies which spend much of their time suspended in midwater, often in the deeper portions of the lake. Plieger (1975) reports that white crappies move into deeper water after spawning, "commonly occurring at depths of 15 feet or more". He also reported that "young crappie are often found over open water of considerable depth". Similarly, Siefert (1969) reported that young crappies moved into the open waters of reservoirs during the summer and Becker (1983) reports that crappies are midwater, open water feeders. Furthermore, several authors have noted the problems associated with accurately estimating crappie (both white and black) numbers in rotenone studies. Swingle and Swingle (1968) note that most rotenone studies take place from July to September and "by this time practically all sizes of crappies have migrated into deeper waters". The two most intensive reservoir rotenone studies conducted in the United States confirm that crappie populations are frequently underestimated. Of nine warmwater species considered by Hayne et al. (1968), only the white crappie was consistently underestimated by rotenone collections. Similarly, Davies and Shelton

(1983) indicate that crappie numbers based on cove rotenone studies have to be increased by as much as 26 fold in order to extrapolate the data to open water portions of reservoirs. Davies and Shelton also reported that crappie data requires greater adjustments than any other species. Thus, it seems quite likely that the true population of crappies in Newton Lake is higher than estimated from the standing crop data (Section 3.3).

In summary, impingement by the Newton Power Station seems to pose little or no threat to fish populations in Newton Lake with the possible exception of the white crappie. The standing crop data (Section 3.3) suggests that the plant impinges 20 percent of white crappies in the lake, which, if true, would adversely affect this species. However, as discussed above, there are several reasons to believe that the true percentage of white crappies impinged is lower, perhaps much lower. Finally, it should be remembered that despite the levels of impingement that do occur, Newton Lake is among the most productive reservoirs in the midwest (see Table 17, Section 3.3) for all species, including crappie.

3.3 STANDING CROP SURVEY

3.3.1 Species Composition

The four areas rotenoned in Newton Lake during 13-16 September 1983 yielded a total of 20 species of fish (Table 9). Numerically, the catch was dominated by gizzard shad, bluegill, and unidentified sunfish (Table 9). For the four locations combined, 184,121 gizzard shad (89.7 percent), 8,499 sunfish spp. (4.1 percent), and 8,316 bluegill (4.1 percent) were captured. Together, these three groups accounted for 97.9 percent of the catch. Other common species (>0.1 percent of the catch) included longear sunfish (1,169 individuals; 0.6 percent), largemouth bass (789; 0.4), channel catfish (618; 0.3), warmouth (404; 0.2), and white crappie (355; 0.2). Species captured in the fewest numbers were bowfin (6 individuals), pugnose minnow (5), and walleye (1). Species that have been reported from the lake (ESE 1982, Price 1983, IDOC 1983, 1984) but which were not captured during this study include redear sunfish (Lepomis microlophus), spotted sucker (Minytrema melanops), white sucker (Catostomus commersoni), hog sucker (Hypentelium nigricans), black bullhead (Ictalurus melas), brown bullhead (Ictalurus nebulosus), suckermouth minnow (Phenacobius mirabilis), grass pickerel (Esox americanus), creek chub-sucker (Erimyzon oblongus), bigmouth buffalo (Ictiobus cyprinellus), black buffalo (Ictiobus niger), and smallmouth buffalo (Ictiobus bubalus). Most of these species are rare or uncommon in the lake so their absence in the present study is not surprising. Also, several are primarily lotic species which have decreased significantly or been extirpated as a result of the lentic habitat created by the formation of Newton Lake. The present study yielded three species not reported previously in Newton Lake: pugnose minnow, tadpole madtom, and Johnny darter. All are small forms that are not readily captured by electrofishing, the gear used in most previous Newton Lake studies.

3.3.2 Catch According to Location

Not surprisingly, the catch varied considerably among the four locations (Tables 10 and 11). As discussed in the sections that follow most of these differences appear to be attributable to differences in habitat (i.e., cove vs non-cove) or temperature. Because of the extremely large catch of gizzard shad (87,353 fish per acre), the warm end cove was 3-12 times more productive than any other area (Table 12). However, if the catch of shad is excluded, the cool end cove becomes the most productive location (7,983 fish per acre) followed closely by the cool end non-cove (6,188), with the two locations in the warm end being decidedly less productive (warm end cove = 1,646; warm end non-cove = 652). No single location was consistently the most productive for all species.

3.3.3 Catch Based on Temperature

Of the 20 species captured, too little data were available to determine which arm of the lake four species preferred (pugnose minnow, walleye, black crappie, and bowfin) (Table 13). The preference (or at least the abundance) of the 16 remaining species is shown in Table 14. Only gizzard

TABLE 9 FISH SPECIES COLLECTED DURING A STANDING CROP SURVEY OF NEWTON LAKE,
SEPTEMBER 1983

<u>Common Name</u>	<u>Scientific Name</u>	<u>Number</u>	<u>Percent Composition</u>
Gizzard shad	<u>Dorosoma cepedianum</u>	184,121	89.7
Bowfin	<u>Amia calva</u>	6	<0.1
Common carp	<u>Cyprinus carpio</u>	102	<0.1
Golden shiner	<u>Notemigonus crysoleucas</u>	99	<0.1
Bluntnose minnow	<u>Pimephales notatus</u>	158	0.1
Pugnose minnow	<u>Notropis emiliae</u>	5	<0.1
Channel catfish	<u>Ictalurus punctatus</u>	618	0.3
Yellow bullhead	<u>Ictalurus natalis</u>	25	<0.1
Tadpole madtom	<u>Noturus gyrinus</u>	79	<0.1
Blackstripe topminnow	<u>Fundulus notatus</u>	59	<0.1
Largemouth bass	<u>Micropterus salmoides</u>	789	0.4
Bluegill	<u>Lepomis macrochirus</u>	8,316	4.1
Green sunfish	<u>Lepomis cyanellus</u>	277	0.1
Longear sunfish	<u>Lepomis megalotis</u>	1,169	0.6
Orangespotted sunfish	<u>Lepomis humilus</u>	182	0.1
Warmouth	<u>Lepomis gulosus</u>	404	0.2
White crappie	<u>Pomoxis annularis</u>	355	0.2
Black crappie	<u>Pomoxis nigromaculatus</u>	6	<0.1
Johnny darter	<u>Etheostoma nigrum</u>	24	<0.1
Walleye	<u>Stizostedion vitreum</u>	1	<0.1
Sunfish spp.	<u>Lepomis spp.</u>	8,499	4.1
Sunfish hybrid	<u>Lepomis spp.</u>	29	<0.1
	TOTAL	205,323	

TABLE 10 NUMBER, WEIGHT AND AVERAGE LENGTH OF EACH SPECIES COLLECTED AT THE TWO COVES ROTENONED IN NEWTON LAKE, 13-16 SEPTEMBER 1983.

Species	Size Group	Cool End Cove			Warm End Cove			Average Length (mm)
		No.	Kg	Lbs	No.	Kg	Lbs	
Gizzard shad	Small	10,167	78.1	171.8	136,214	927.0	2,039.4	(92.4) ^a
	Medium	881	41.2	90.7	1,708	60.8	133.7	173.9
	Large	59	6.1	13.4	61	7.2	15.9	226.7
	Total	11,107	125.4	275.9	137,983	995.0	2,189.0	93.5
Bowfin	Large	6	21.2	46.6	- _b	-	-	-
Carp	Small	7	0.5	1.0	18	1.9	4.1	197.4
	Medium	12	6.9	15.2	24	13.6	29.9	346.5
	Large	32	39.8	87.5	5	5.2	11.5	436.0
	Total	51	47.2	103.7	47	20.7	45.5	298.9
Golden shiner	Total	94	0.8	1.7	2	<0.1	<0.1	78.5
Bluntnose minnow	Total	47	<0.1	<0.1	3	<0.1	<0.1	64.0
Pugnose minnow	Total	2	<0.1	<0.1	-	-	-	-
Channel catfish	Small	34	1.4	3.0	236	2.2	4.9	103.3
	Medium	60	12.0	26.4	51	6.3	13.9	245.7
	Large	5	8.6	19.1	11	9.2	20.3	428.0
	Total	99	22.0	48.5	298	17.7	39.1	139.6
Yellow bullhead	Total	22	0.3	0.8	1	<0.1	<0.1	144.0
Tadpole madtom	Total	57	0.1	0.2	-	-	-	-
Blackstripe topminnow	Total	54	0.1	0.2	3	<0.1	<0.1	47.7
Largemouth bass	Small	248	0.9	1.9	47	0.5	1.2	84.8
	Medium	23	8.3	18.3	23	0.5	1.1	236.3
	Large	6	6.6	14.5	10	8.0	17.6	378.4
	Total	277	15.8	34.7	80	9.0	19.9	165.1

TABLE 10 (CONT.)

Species	Size Group	Cool End Cove				Warm End Cove			
		No.	Kg	Lbs	Average Length(mm)	No.	Kg	Lbs	Average Length(mm)
Bluegill	Small	812	0.9	2.0	41.3	-	-	-	-
	Medium	720	13.1	28.7	106.5	620	8.6	18.8	93.9
	Large	-	-	-	-	307	11.8	26.1	135.4
	Total	1,532	14.0	30.7	71.9	927	20.4	44.9	107.6
Green sunfish	Small	121	0.2	0.5	44.6	21	0.1	0.2	67.1
	Medium	54	0.7	1.6	91.5	44	0.9	2.0	109.7
	Large	5	0.2	0.4	133.0	4	0.2	0.5	154.8
	Total	180	1.1	2.5	61.1	69	1.2	2.7	99.4
Longear sunfish	Small	94	0.9	2.1	84.8	376	4.6	10.1	87.0
	Medium	207	3.3	7.2	99.5	182	3.8	8.4	104.3
	Large	25	0.7	1.6	116.5	-	-	-	-
	Total	326	4.9	10.9	96.6	558	8.4	18.5	92.6
Orangespotted sunfish	Small	48	0.1	0.2	45.3	32	0.2	0.4	70.4
	Medium	38	0.2	0.5	68.1	-	-	-	-
	Large	86	0.3	0.7	55.3	32	0.2	0.4	70.4
	Total	178	0.3	0.6	42.2	2	<0.1	<0.1	41.5
Warmouth	Small	83	0.6	1.4	70.9	3	0.1	0.2	131.3
	Medium	18	0.9	2.0	141.7	-	-	-	-
	Large	279	1.8	4.0	57.2	5	0.1	0.2	95.4
	Total	3,654	4.0	8.8	-	66	0.3	0.7	48.1
Sunfish spp.	Small	2,409	2.7	5.9	-	548	3.8	8.3	99.1
	Medium	6,063	6.7	14.7	-	614	4.1	9.0	93.6
	Large	-	-	-	-	-	-	-	-
	Total	-	-	-	-	-	-	-	-
Sunfish hybrid	Small	14	0.2	0.4	94.3	3	<0.1	<0.1	66.7
	Medium	43	3.5	7.7	187.7	7	0.6	1.3	190.7
	Large	33	8.1	17.9	257.3	4	0.8	1.7	242.5
	Total	90	11.8	26.0	198.7	14	1.4	3.0	178.9
White crappie	Small	14	0.2	0.4	94.3	3	<0.1	<0.1	66.7
	Medium	43	3.5	7.7	187.7	7	0.6	1.3	190.7
	Large	33	8.1	17.9	257.3	4	0.8	1.7	242.5
	Total	90	11.8	26.0	198.7	14	1.4	3.0	178.9

TABLE 10 (CONT.)

<u>Species</u>	<u>Size Group</u>	<u>Cool End Cove</u>				<u>Warm End Cove</u>			
		<u>No.</u>	<u>Kg</u>	<u>Lbs</u>	<u>Average Length (mm)</u>	<u>No.</u>	<u>Kg</u>	<u>Lbs</u>	<u>Average Length (mm)</u>
Black crappie	Medium	-	-	-	-	-	-	-	-
	Large	-	-	-	-	-	-	-	-
	Total	3	0.2	0.5	181.0	-	-	-	-
Johnny darter	Total	16	<0.1	<0.1	-	-	-	-	-
Walleye	Total	-	-	-	-	1	2.0	4.4	616.0
Total		20,391	273.7	602.3		140,637	1080.2	2376.6	
Number of Species		19				15			

(a) Average length in parenthesis based on average from other three areas.
 (b) No fish collected from the sampling area.

TABLE 11 NUMBER, WEIGHT, AND MEAN LENGTH OF EACH SPECIES COLLECTED BY ROTENONING AT THE TWO NON-COVE AREAS AND ALL AREAS COMBINED IN NEWTON LAKE, SEPTEMBER 1983

Species	Size Group	Cool End Non-Cove				Warm End Non-Cove				Combined Areas			
		No.	Kg	Lbs	Average Length(mm)	No.	Kg	Lbs	Average Length(mm)	No.	Kg	Lbs	Average Length(mm)
Gizzard shad	Small	705	4.3	9.5	90.6	32,283	220.2	484.4	88.6	179,369	1,229.6	2,705.1	92.0
	Medium	275	16.1	35.5	180.1	1,677	83.1	182.8	172.3	4,541	201.2	442.7	174.3
	Large	73	9.3	20.5	225.1	18	1.9	4.4	229.5	211	24.5	54.2	225.5
	Total	1,053	29.7	65.5	123.3	33,978	305.2	671.6	92.8	184,121	1,455.3	3,202.0	94.2
Bowfin	Large	-	-	-	-	-	-	-	-	6	21.2	46.6	665.8
Carp	Small	-	-	-	-	-	-	-	-	25	2.4	5.1	191.3
	Medium	-	-	-	-	3	1.4	3.1	343.7	39	21.9	48.2	348.9
	Large	1	0.5	1.2	350.0	-	-	-	-	38	45.5	100.2	453.6
	Total	1	0.5	1.2	350.0	3	1.4	3.1	343.7	102	69.8	153.5	349.3
Golden shiner	Total	3	<0.1	<0.1	74.0	-	-	-	-	99	0.8	1.7	97.6
Bluntnose minnow	Total	108	0.6	1.4	61.3	-	-	-	-	158	0.6	1.4	61.0
Pugnose minnow	Total	3	<0.1	<0.1	-	-	-	-	-	5	<0.1	<0.1	-
Channel catfish	Small	3	<0.1	<0.1	85.7	8	0.2	0.4	106.2	281	3.8	8.3	111.4
	Medium	32	4.6	10.1	252.9	114	12.6	27.8	246.6	257	35.5	78.2	270.8
	Large	63	23.9	52.7	362.5	1	1.6	3.5	512.0	80	43.3	95.6	384.7
	Total	98	28.5	62.8	318.2	123	14.4	31.7	239.6	618	82.6	182.1	213.0
Yellow bullhead	Total	2	0.1	0.3	156.5	-	-	-	-	25	0.4	1.1	102.6
Tadpole madtom	Total	22	<0.1	<0.1	52.1	-	-	-	-	79	0.1	0.3	52.2
Blackstripe topminnow	Total	2	<0.1	<0.1	40.0	-	-	-	-	59	0.1	0.2	49.5
Largemouth bass	Small	285	1.6	3.6	79.6	22	0.1	0.2	68.7	602	3.1	6.9	73.6
	Medium	20	4.7	10.3	261.5	15	2.9	6.3	213.6	81	16.4	36.0	254.6
	Large	66	58.4	128.5	368.1	24	22.8	50.2	384.3	106	95.8	210.8	375.8
	Total	371	64.7	142.4	140.7	61	25.8	56.7	228.5	789	115.3	253.7	132.8

TABLE 12 COMPARISON OF THE CATCH (BY NUMBER AND WEIGHT) AMONG FOUR AREAS ROTENONED IN NEWTON LAKE, SEPTEMBER 1983

Species	Size Group	Cool End Cove			Warm End Cove			Cool End Non-Cove			Warm End Non-Cove		
		No./ Acre	lbs./ Acre	kg/ ha	No./ Acre	lbs./ Acre	kg/ ha	No./ Acre	lbs./ Acre	kg/ ha	No./ Acre	lbs./ Acre	kg/ ha
Gizzard shad	Small	7,644	129.2	145.0	84,605	1,266.7	1,422.2	522	7.0	7.9	22,734	341.7	383.1
	Medium	662	68.2	76.6	1,061	83.0	93.4	204	26.3	29.4	1,181	128.7	144.5
	Large	44	10.1	11.4	38	9.9	11.1	51	15.2	17.0	13	3.1	3.2
	Total	8,350	207.5	233.0	85,704	1,359.6	1,526.7	777	48.5	54.3	23,928	473.5	530.8
Bowfin	Total	5	35.0	39.3	-	-	-	-	-	-	-	-	-
Carp	Small	5	0.1	1.0	11	2.5	3.0	-	-	-	-	-	-
	Medium	9	11.4	12.8	15	18.6	20.7	-	-	-	-	-	-
	Large	24	65.8	73.9	3	7.1	7.9	1	0.9	1.0	2	2.2	2.5
	Total	38	77.3	87.7	29	28.2	31.6	1	0.9	1.0	2	2.2	2.5
Golden shiner	Total	71	1.3	1.5	1	<0.1	<0.1	2	<0.1	<0.1	-	-	-
Bluntnose minnow	Total	35	<0.1	<0.1	2	<0.1	<0.1	80	1.0	1.0	-	-	-
Pugnose minnow	Total	2	<0.1	<0.1	-	-	-	2	<0.1	<0.1	-	-	-
Channel catfish	Small	26	2.3	2.7	147	3.0	3.5	2	<0.1	<0.1	13	0.3	0.3
	Medium	45	19.8	22.2	32	8.6	9.6	24	7.5	8.4	80	19.6	22.0
	Large	4	14.4	16.1	7	12.6	14.1	47	39.0	43.7	1	2.5	2.7
	Total	75	36.5	41.0	186	24.2	27.2	73	46.5	52.1	94	22.4	25.0
Yellow bullhead	Total	17	0.5	0.5	1	<0.1	<0.1	2	0.2	0.3	-	-	-
Tadpole madtom	Total	43	0.1	0.2	-	-	-	16	0.1	0.1	-	-	-
Blackstripe topminnow	Total	41	0.2	0.2	2	<0.1	<0.1	2	<0.1	<0.1	-	-	-
Largemouth bass	Small	186	1.4	1.7	29	0.7	0.7	211	2.7	3.0	16	0.1	0.2
	Medium	17	13.8	15.3	14	0.7	0.7	15	7.6	8.6	11	4.4	4.9
	Large	5	10.9	12.4	6	10.9	12.4	49	95.2	107.0	17	35.4	39.8
	Total	208	26.1	29.4	49	12.3	13.8	275	105.5	118.6	44	39.9	44.9
Bluegill	Small	610	1.5	1.7	-	-	-	2,517	9.9	11.1	39	0.2	0.3
	Medium	541	21.6	24.2	385	11.7	13.1	1,048	23.6	26.4	223	8.3	9.4
	Large	-	-	-	191	16.2	18.0	471	24.7	27.7	25	2.0	2.2
	Total	1,151	23.1	25.9	576	27.9	31.1	4,036	58.2	65.2	287	10.5	11.9
Green sunfish	Small	91	0.4	0.5	13	0.1	0.2	-	-	-	-	-	-
	Medium	41	1.2	1.2	27	1.2	1.5	-	-	-	-	-	-
	Large	4	0.3	0.5	3	0.3	0.3	-	-	-	-	-	-
	Total	136	1.9	2.2	43	1.6	2.0	19	0.3	0.5	1	0.1	0.1
Longear sunfish	Small	71	1.6	1.7	234	6.3	7.2	-	-	-	-	-	-
	Medium	156	5.4	6.2	113	5.2	5.9	142	4.4	4.9	65	2.5	2.7
	Large	19	1.2	1.2	-	-	-	1	0.1	0.2	-	-	-
	Total	246	8.2	9.1	347	11.5	13.1	143	4.5	5.1	65	2.5	2.7
Orangespotted sunfish	Small	36	0.2	0.3	20	0.2	0.3	-	-	-	-	-	-
	Medium	29	0.4	0.5	-	-	-	-	-	-	-	-	-
	Total	65	0.6	0.8	20	0.2	0.3	47	0.4	0.5	-	-	-
Warmouth	Small	134	0.5	0.5	1	<0.1	<0.1	63	0.5	0.5	-	-	-
	Medium	62	1.1	1.2	2	0.1	0.2	15	0.8	1.0	-	-	-
	Large	14	1.5	1.7	-	-	-	11	1.6	1.7	-	-	-
	Total	210	3.1	3.4	3	0.1	0.2	89	2.9	3.2	-	-	-
Sunfish spp.	Small	2,747	6.6	7.4	41	0.4	0.5	1,350	5.3	5.9	-	-	-
	Medium	1,811	4.4	4.9	340	5.2	5.9	-	-	-	-	-	-
	Total	4,558	11.0	12.3	381	5.6	6.4	1,350	5.3	5.9	-	-	-
Sunfish hybrid	Total	-	-	-	-	-	-	11	1.0	1.0	10	0.1	0.2
White crappie	Small	11	0.3	0.5	2	<0.1	<0.1	1	<0.1	<0.1	122	0.4	0.5
	Medium	32	5.8	6.4	4	0.8	1.0	8	1.1	1.2	9	1.3	1.5
	Large	25	13.5	15.1	3	1.1	1.2	21	9.0	10.1	18	5.6	6.2
	Total	68	19.6	22.0	9	1.9	2.2	30	10.1	11.3	149	7.3	8.2

TABLE 12 (CONT.)

Species	Size Group	Cool End Cove			Warm End Cove			Cool End Non-Cove			Warm End Non-Cove		
		No./ Acre	lbs./ Acre	kg/ ha	No./ Acre	lbs./ Acre	kg/ ha	No./ Acre	lbs./ Acre	kg/ ha	No./ Acre	lbs./ Acre	kg/ ha
Black crappie	Medium	-	-	-	-	-	-	2	0.1	0.1	-	-	-
	Large	2	0.4	0.5	-	-	-	1	0.4	0.4	-	-	-
	Total	2	0.4	0.5	-	-	-	3	0.5	0.5	-	-	-
Johnny darter	Total	12	<0.1	<0.1	-	-	-	6	<0.1	<0.1	-	-	-
Walleye	Total	-	-	-	-	-	-	1	3.3	3.7	-	-	-
TOTAL		15,333	452.4	509.0	87,353	1,473.0	1,654.6	6,965	289.2	324.3	24,580	552.5	626.3

TABLE 13 COMPARISON OF THE ROTENONE CATCH IN SEPTEMBER 1983 BETWEEN THE WARM AND COOL ENDS OF NEWTON LAKE

Species	Size Group	X Warm End			X Cool End		
		No./Acre	Lbs/Acre	Kg/ha	No./Acre	Lbs/Acre	Kg/ha
Gizzard shad	Small	53,669	804.2	902.7	4,083	68.1	76.5
	Medium	1,121	105.9	118.9	433	47.3	53.0
	Large	26	6.5	7.1	47	12.7	14.2
	Total	54,816	916.6	1,028.7	4,563	128.1	143.7
Bowfin	Total	-	-	-	2	17.5	19.7
Carp	Small	5	1.3	1.5	3	0.1	0.5
	Medium	9	10.4	11.6	5	5.7	6.4
	Large	1	3.5	3.9	13	33.4	37.5
	Total	15	15.2	17.0	21	39.2	44.4
Golden shiner	Total	1	<0.1	<0.1	36	0.7	0.8
Bluntnose minnow	Total	1	<0.1	<0.1	57	0.5	0.5
Pugnose minnow	Total	-	-	-	2	<0.1	<0.1
Channel catfish	Small	80	1.7	1.8	14	1.2	1.4
	Medium	56	14.1	15.8	35	13.7	15.3
	Large	4	7.5	8.4	25	26.7	29.9
	Total	140	23.3	26.0	74	41.6	46.6
Yellow bullhead	Total	1	<0.1	<0.1	9	0.3	0.4
Tadpole madtom	Total	-	-	-	29	0.1	0.1
Blackstripe topminnow	Total	1	<0.1	<0.1	21	0.1	0.1
Largemouth bass	Small	23	0.4	0.5	199	2.1	2.3
	Medium	13	2.5	2.8	16	10.7	11.9
	Large	11	23.1	26.1	27	53.1	59.7
	Total	47	26.0	29.4	242	65.9	73.9

TABLE 13 (CONT.)

Species	Size Group	\bar{X} Warm End		\bar{X} Cool End	
		No./Acre	Lbs/Acre	No./Acre	Lbs/Acre
			Kg/ha		Kg/ha
Bluegill	Small	20	0.1	1,563	5.7
	Medium	304	10.0	795	22.6
	Large	108	9.1	235	12.3
	Total	432	19.2	2,593	40.6
Green sunfish	Small	7	0.1	45	0.2
	Medium	13	0.6	21	0.6
	Large	1	0.1	2	0.1
	Total	21	0.8	68	0.9
Longear sunfish	Small	117	3.1	35	0.8
	Medium	89	3.9	149	4.9
	Large	-	-	10	0.7
	Total	206	7.0	194	6.4
Orangespotted sunfish	Small	10	0.1	18	0.1
	Medium	-	-	15	0.2
	Total	10	0.1	33	0.3
Warmouth	Small	1	<0.1	99	0.5
	Medium	1	0.1	39	0.9
	Large	-	-	13	1.5
	Total	2	0.2	151	2.9
Sunfish spp.	Small	21	0.2	2,049	5.9
	Medium	170	2.6	906	2.2
	Total	191	2.8	2,955	8.1
Sunfish hybrid	Total	5	0.1	5	0.5
White crappie	Small	62	0.2	6	0.2
	Medium	7	1.1	20	3.5
	Large	11	3.3	23	11.3
	Total	80	4.6	49	15.0

TABLE 13 (CONT.)

Species	Size Group	\bar{X} Warm End		\bar{X} Cool End	
		No./Acre	Lbs/Acre	No./Acre	Lbs/Acre
Black crappie	Medium	-	-	1	0.1
	Large	-	-	1	0.4
	Total	-	-	2	0.5
Johnny darter					0.6
	Total	-	-	9	<0.1
Walleye					
	Total	-	-	1	1.7
TOTAL		55,969	1,015.9	11,116	370.9
TOTAL (except for Gizzard shad)		1,153	99.3	6,553	242.8
					416.7
					273.0

TABLE 14 TEMPERATURE PREFERENCES OF NEWTON LAKE FISHES BASED ON THE RESULTS OF THE SEPTEMBER ROTENONE SURVEY

<u>Preferred Cool End (Ratio*)</u>	<u>Preferred Warm End (Ratio)</u>	<u>No Preference</u>
Warmouth (75:1)	Gizzard shad (12:1)	Common carp
Bluntnose minnow (57:1)		Longear sunfish
Golden shiner (36:1)		Channel catfish
Tadpole madtom (>29:1)		White crappie
Blackstripe topminnow (21:1)		
Sunfish spp. (15:1)		
Johnny darter (>9:1)		
Yellow bullhead (9:1)		
Bluegill (6:1)		
Largemouth bass (5:1)		
Green sunfish (3:1)		
Orangespotted sunfish (3:1)		

* Ratio of the number of fish in the preferred arm to the number of fish in the other arm.

shad preferred the warm arm (end) of the lake, being 12 times more abundant there. Conversely, 11 species preferred the cool end of the lake (Table 14). The preference ratios for these species ranged from 3:1 to 75:1. Furthermore, six species (tadpole madtom, Johnny darter, bowfin, pugnose minnow, black crappie, and walleye) were found only in the cool end of the lake. Among the common species, the distribution of warmouth was most dramatically affected, as it was confined almost entirely to the cool end of the lake.

Carp and longear sunfish were equally abundant in both arms of the lake. Channel catfish and white crappie showed mixed preferences depending on size (age). Overall, channel catfish were twice as abundant in the warm end of the lake (Table 13) due to a large number of YOY fish; however, the biomass of channel catfish was twice as high in the cool end of the lake. This was primarily the result of many more large channel catfish being collected in the cool end (Table 13). White crappie followed the same pattern as channel catfish. That is, in terms of numbers they were more abundant in warm end of the lake, but their biomass was greatest in the cool end.

Because the present study was conducted during only one period of the year, it is not possible to be certain whether the distributional differences described above would hold during other times of the year. However, given the territorial and/or non-migratory nature of the species in Newton Lake, it seems likely that these patterns hold up during all or most of the year.

3.3.4 Catch Based on Habitat

As with temperature, too little data were available to determine the habitat preference of bowfin, pugnose minnow, walleye, and black crappie (Table 15). The preferences of the remaining 16 species are presented in Table 16. Ten species preferred the cove habitat; all were more abundant, both numerically and in terms of biomass in the coves. The strongest preferences for or association with coves was exhibited by golden shiner, blackstripe topminnow, and common carp.

Three species (white crappie, bluegill, and bluntnose minnow) were more abundant in the non-cove habitats. However, their preferences were not pronounced as ratios were only 2-3:1. Channel catfish, largemouth bass, and Johnny darters did not exhibit clear-cut preferences for either habitat. Though not exhibiting any preference based on total numbers, large channel catfish and largemouth bass were noticeably more abundant in the non-cove areas. Similarly, most of the large bluegill were captured in the non-cove habitats (Table 15). These data suggest that the cove areas are nursery areas that harbor primarily YOY and juvenile fishes, while the adults of many species seek out the open water, deeper portions of the lake (at least during late summer).

If gizzard shad are excluded from the totals shown in Table 15, the differences between coves and non-coves are reduced considerably. For example, there are an average of 4,326 non-shad per acre in cove areas compared to 3,428 per acre in non-cove areas, a ratio of only 1.3:1. Similarly, the biomass estimate (202.5 kg/acre) for non-shad in the cove habitats is only 1.2 times greater than in non-cove habitats (168.1 kg/ha).

TABLE 15 COMPARISON OF THE NUMBER AND BIOMASS OF FISH IN COVES, NON-COVES, AND ALL OF NEWTON LAKE BASED ON ROTENONE STUDIES CONDUCTED SEPTEMBER 1983

Species	Size Group	Cove			Non-Cove			Entire Reservoir			Population Estimate		
		No./Acre	lbs./Acre	kg/ha	No./Acre	lbs./Acre	kg/ha	No./Acre	lbs./Acre	kg/ha	No.	% of Total	% of Total
Gizzard shad	Small	46,125	698.0	783.6	11,628	174.4	195.5	21,390	322.5	361.9	38,266,710	82.78	262,016 55.89
	Medium	862	75.6	85.0	693	77.5	87.0	741	77.0	86.4	1,325,649	2.86	62,554 13.34
	Large	41	10.0	11.3	32	9.2	10.1	35	9.4	10.4	62,615	0.14	7,530 1.61
	Total	46,028	783.6	879.9	12,353	261.1	292.6	22,166	408.9	458.7	39,654,974	85.78	332,100 70.84
Bowfin	Total	3	17.5	19.7	-	-	-	1	5.0	5.5	1,789	<0.01	3,982 0.85
Carp	Small	8	1.3	2.0	-	-	-	2	0.4	0.6	3,578	0.01	434 0.09
	Medium	12	15.0	16.8	1	1.1	1.3	4	5.0	5.7	7,156	0.02	4,127 0.88
	Large	14	36.5	40.9	1	0.5	0.5	5	10.7	11.9	8,945	0.02	8,616 1.84
	Total	34	52.8	59.7	2	1.6	1.8	11	16.1	18.2	19,679	0.04	13,177 2.81
Golden shiner	Total	36	0.7	0.8	1	<0.1	<0.1	11	0.2	0.2	19,679	0.04	145 0.03
Bluntnose minnow	Total	19	<0.1	<0.1	40	0.5	0.5	34	0.4	0.4	60,826	0.13	290 0.06
Pugnose minnow	Total	1	<0.1	<0.1	1	<0.1	<0.1	1	<0.1	<0.1	1,789	<0.01	<0.1<0.01
Channel catfish	Small	87	2.7	3.1	8	0.2	0.2	30	0.9	1.0	53,670	0.12	724 0.15
	Medium	39	14.2	15.9	52	13.6	15.2	48	13.8	15.4	85,872	0.19	11,150 2.38
	Large	6	13.5	15.1	24	20.8	23.2	19	18.7	20.9	33,991	0.07	15,132 3.23
	Total	132	30.4	34.1	84	34.6	38.6	97	33.4	37.3	173,533	0.38	27,006 5.76
Yellow bullhead	Total	9	0.3	0.3	1	0.1	0.2	3	0.2	0.2	5,367	0.01	145 0.03
Tadpole madtom	Total	22	0.1	0.1	8	0.1	0.1	12	0.1	0.1	21,468	0.05	72 0.02
Blackstripe topminnow	Total	22	0.1	0.1	1	<0.1	<0.1	7	0.1	0.1	12,523	0.03	72 0.02
Largemouth bass	Small	108	1.1	1.2	114	1.4	1.6	112	1.3	1.5	200,368	0.43	1,086 0.23
	Medium	16	7.3	8.0	13	6.0	6.8	14	6.4	7.1	25,046	0.05	5,140 1.10
	Large	6	10.9	12.4	33	65.3	73.4	25	49.9	56.1	44,725	0.10	40,616 8.66
	Total	130	19.3	21.6	160	72.7	81.8	151	57.6	64.7	270,139	0.58	46,842 9.99
Bluegill	Small	305	0.7	0.8	1,278	5.0	5.7	1,003	3.8	4.3	1,794,367	3.89	3,113 0.66
	Medium	463	16.7	18.7	636	16.0	17.9	587	16.2	18.1	1,050,143	2.27	13,104 2.80
	Large	96	8.1	9.0	248	13.4	15.0	205	11.9	13.4	366,745	0.79	9,702 2.07
	Total	864	25.5	28.5	2,162	34.4	38.6	1,795	31.9	35.8	3,211,255	6.95	25,919 5.53
Green sunfish	Small	52	0.3	0.4	-	-	-	15	0.1	0.1	26,835	0.06	72 0.02
	Medium	34	1.2	1.4	-	-	-	10	0.3	0.4	17,890	0.04	290 0.06
	Large	4	0.3	0.4	-	-	-	1	0.1	0.1	1,789	<0.01	72 0.02
	Total	90	1.8	2.2	10	0.2	0.3	33	0.7	0.9	59,037	0.13	652 0.14
Longear sunfish	Small	153	4.0	4.5	-	-	-	43	1.1	1.3	76,927	0.17	941 0.20
	Medium	135	5.3	6.1	104	3.5	3.8	113	4.0	4.5	202,157	0.44	3,258 0.69
	Large	10	0.6	0.6	1	0.1	0.1	4	0.2	0.2	7,156	0.02	145 0.03
	Total	298	9.9	11.2	105	3.6	3.9	160	5.3	6.0	286,240	0.62	4,344 0.93

TABLE 15 (CONT.)

Species	Size Group	X Cove			X Non-Cove			X Entire Reservoir			Population Estimate		
		No./ Acre	lbs./ Acre	kg/ ha	No./ Acre	lbs./ Acre	kg/ ha	No./ Acre	lbs./ Acre	kg/ ha	No.	% of Total	% of Total
Orangespotted sunfish	Small	28	0.2	0.3	-	-	-	8	0.1	0.1	14,312	0.03	72
	Medium	15	0.2	0.3	-	-	-	4	0.1	0.1	7,156	0.02	72
	Total	43	0.4	0.6	24	0.2	0.3	29	0.3	0.4	51,881	0.11	290
Warmouth	Small	68	0.3	0.3	32	0.3	0.3	42	0.3	0.3	75,138	0.16	217
	Medium	32	0.6	0.7	8	0.4	0.4	15	0.5	0.6	26,835	0.06	434
	Large	7	0.8	0.9	6	0.8	0.9	6	0.8	0.9	10,734	0.02	552
	Total	107	1.7	1.9	46	1.5	1.7	63	1.6	1.7	112,707	0.24	1,303
Sunfish spp.	Small	1,394	3.5	4.0	675	2.7	2.9	878	2.9	3.2	1,570,742	3.40	2,317
	Medium	1,076	4.8	5.4	-	-	-	305	1.4	1.5	545,645	1.18	1,086
	Total	2,470	8.3	9.4	675	2.7	2.9	1,183	4.3	4.7	2,116,387	4.58	3,403
Sunfish hybrid	Total	-	-	-	11	0.5	0.6	8	0.4	0.4	14,312	0.03	290
White crappie	Small	7	0.2	0.3	62	0.2	0.3	46	0.2	0.3	82,294	0.18	217
	Medium	18	3.3	3.7	9	1.2	1.4	12	1.8	2.1	21,468	0.05	1,520
	Large	14	7.3	8.2	20	7.3	8.2	18	7.3	8.2	32,202	0.07	5,937
	Total	39	10.8	12.2	91	8.7	9.9	76	9.3	10.6	135,964	0.29	7,674
Black crappie	Medium	-	-	-	1	0.1	0.1	1	0.1	0.1	1,789	<0.01	72
	Large	1	0.2	0.3	1	0.2	0.2	1	0.2	0.3	1,789	<0.01	217
	Total	1	0.2	0.3	2	0.3	0.3	2	0.3	0.4	3,578	0.01	290
Johnny darter	Total	6	<0.1	<0.1	3	<0.1	<0.1	4	<0.2	<0.2	7,156	0.02	<0.1
Walleye	Total	-	-	-	1	1.7	1.9	1	1.2	1.4	1,789	<0.01	1,014
TOTAL		50,354	963.4	1082.6	15,781	427.2	480.7	25,841	577.1	647.4	46,242,072		469,010

TABLE 16 HABITAT (COVE VS NON-COVE) PREFERENCES OF NEWTON LAKE FISHES
BASED ON THE RESULTS OF THE SEPTEMBER ROTENONE SURVEY

<u>Prefers Coves (Ratio*)</u>	<u>Prefers Non-Coves (Ratio)</u>	<u>No Preference</u>
Golden shiner (36)	White crappie (3)	Channel catfish
Blackstripe topminnow (22)	Bluegill (3)	Johnny darter
Common carp (17)	Bluntnose minnow (2)	Largemouth bass
Green sunfish (9)		
Yellow bullhead (9)		
Gizzard shad (4)		
Sunfish spp. (4)		
Tadpole madtom (3)		
Longear sunfish (3)		
Orangespotted sunfish (2)		
Warmouth (2)		

* Ratio of the number of fish in their preferred habitat to the number in the non-preferred habitat.

3.3.5 Population Estimates

When the average number of fish per acre for cove and non-cove habitats is extrapolated (based on the proportional occurrence of each habitat type) to the entire lake, the population estimate for Newton Lake is over 46 million fish (Table 15), of which nearly 40 million are gizzard shad. Estimates for other common species are: bluegill (3.2 million), sunfish spp. (2.1 million), longear sunfish (0.3 million), largemouth bass (0.3 million), channel catfish (0.2 million), white crappie (0.1 million), and warmouth (0.1 million). These eight groups accounted for 99.4 percent of the number and 95.6 percent of the biomass in the lake. Carp, although relatively low in number, contributes 2.8 percent of the biomass.

The biomass estimates for Newton Lake compare favorably with the results of other studies. In fact, the total standing crop for Newton Lake (647.4 kg/ha) is higher than any of the other lakes with which it can be compared (Table 17). Similarly, the biomass of gizzard shad is higher than in any of the lakes shown in Table 17, except Dresden Pond. Thus, the forage base in Newton Lake was excellent in 1983. With regard to sport species, the standing crop in Newton Lake ranks at or near the top for channel catfish, bluegill, largemouth bass, and white crappie. The value of 64.7 kg/ha for largemouth bass in Newton Lake is particularly high, being 3 to >60 times higher than in other lakes (Table 17).

3.3.6 Length Distributions of Selected Fishes

Gizzard shad

The gizzard shad community in Newton Lake in September of 1983 was dominated by YOY fish; 97.4 percent of the catch was <120 mm (Figure 7). There was also a small group (2.5 percent) of shad between 150 and 210 mm that are probably Age I fish. Very few (0.1 percent) large shad (Age II+, >210 mm) were found. Certainly, there was a very good hatch of gizzard shad in Newton Lake in 1983.

Channel catfish

YOY channel catfish constituted 44.2 percent of the catch, while another 24.8 percent were probably Age I fish, 200-249 mm (Figure 8). Thirty one percent of the channel catfish collected were 250 mm in length or greater, the size sought by anglers. Given the 173,533 channel catfish estimated to be in the lake (Table 15), it can be calculated that the lake contains nearly 54,000 channel catfish in the "keeper" category.

Largemouth bass

YOY largemouth bass (<100 mm) constituted 69.6 percent of the bass captured (Figure 9). Conversely, 17.9 percent of the largemouth bass were 260 mm (10") or more in length. Legal size bass (>457 mm) constituted one percent of the catch. Therefore, based on the 270,000+ bass estimated to be in the lake (Table 15), it can be estimated that in September of 1983 there were 2700 legal bass available to anglers.

TABLE 17 BIOMASS ESTIMATES (kg/ha) OF SELECTED SPECIES FROM ILLINOIS RESERVOIRS

	Coffeen ¹ Lake	Lake Sangchris ²	Lake Shelbyville ²	Newton Lake	Midwest ³	Mid-South ⁴	Dresden Pond ⁵ 1980-82 1983
Gizzard Shad	267.5	275.3	294.0	458.7	204	92	- 531
Carp	13.9	27.0	70.8	18.2	73	25	58.1 21.8
Channel Catfish	34.6	9.5	2.6	37.3	14	9	36.7 31.8
Bluegill	52.1	22.8	22.7	35.8	42	21	2.2 2.0
Largemouth Bass	7.7	3.5	12.6	64.7	19	10	0.8 <0.1
White Crappie	4.6	0.5	4.0	10.6	26	5	<0.1 -
Lepomis sp.	101.5	25.6	30.5	14.1	-	31	9.2 4.9
All Species	437.8	360.9	449.6	647.4	398	202	- 659

1 Illinois Natural History Survey 1981

2 Tranquilli et al. 1979

3 Carlander 1955

4 Jenkins 1975

5 CECO (unpublished data)

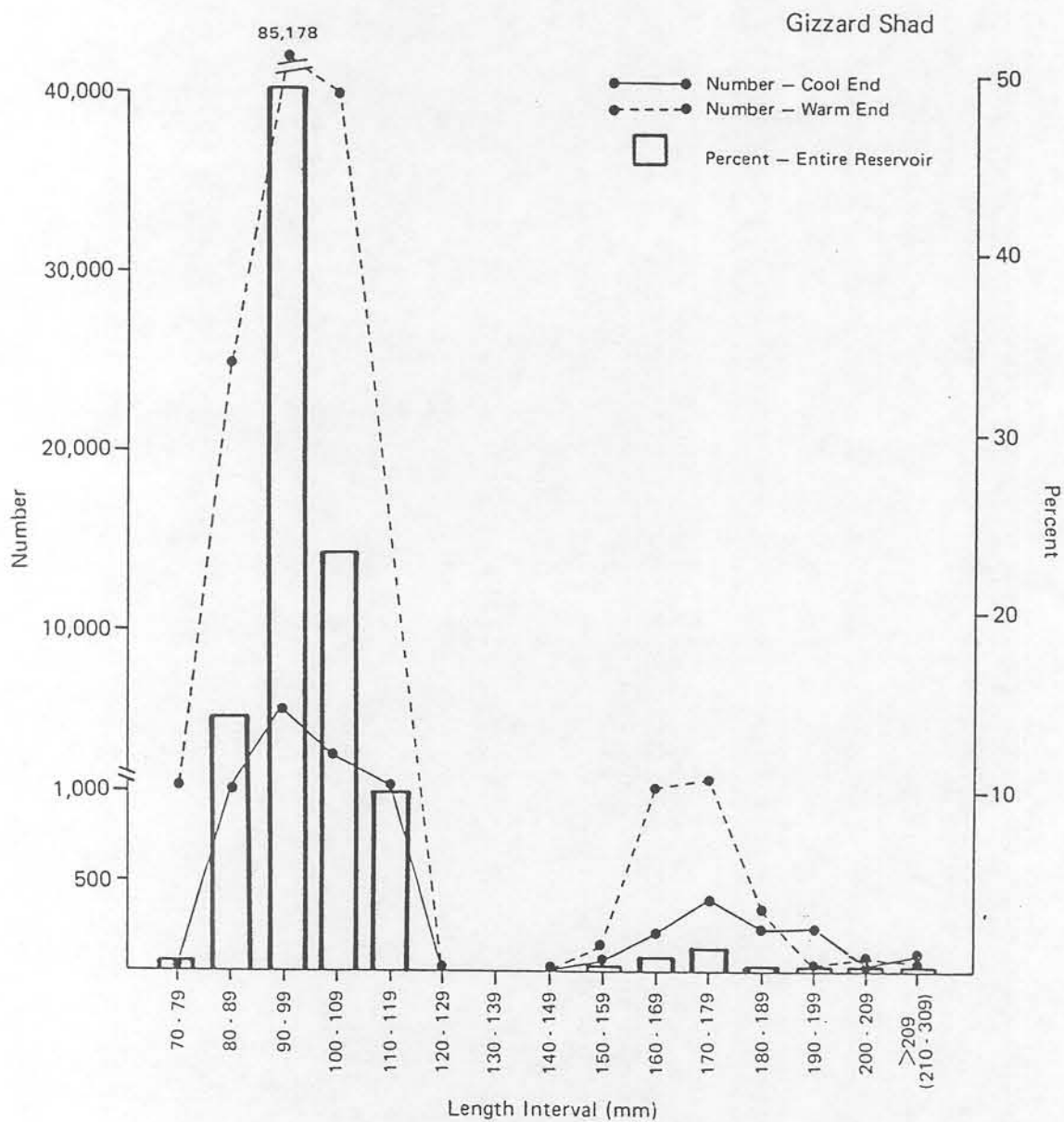


Figure 7. Length frequency distributions of gizzard shad collected during a rotenone survey of Newton Lake, September 1983.

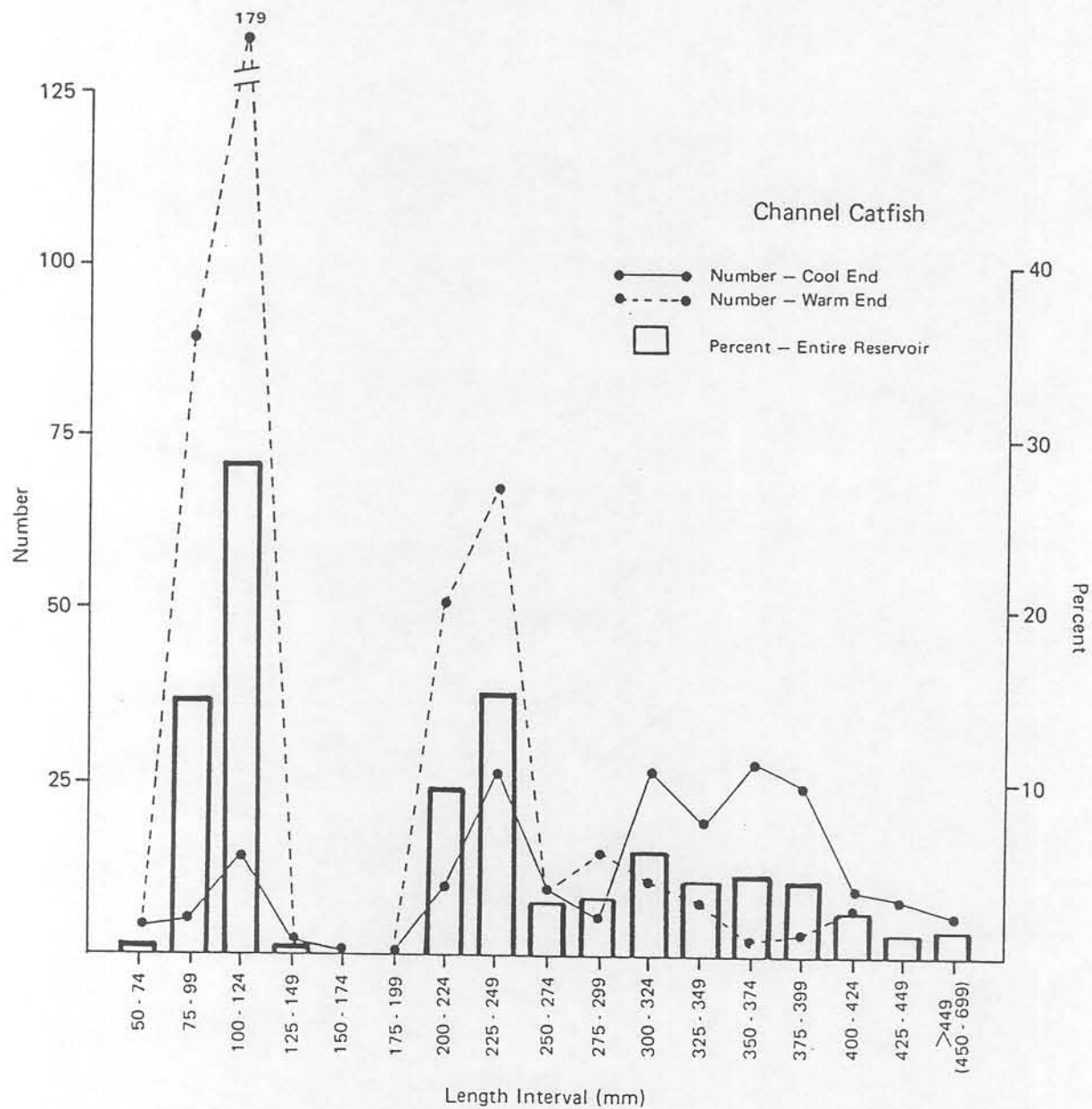


Figure 8. Length frequency distributions of channel catfish collected during a rotenone survey of Newton Lake, September 1983.

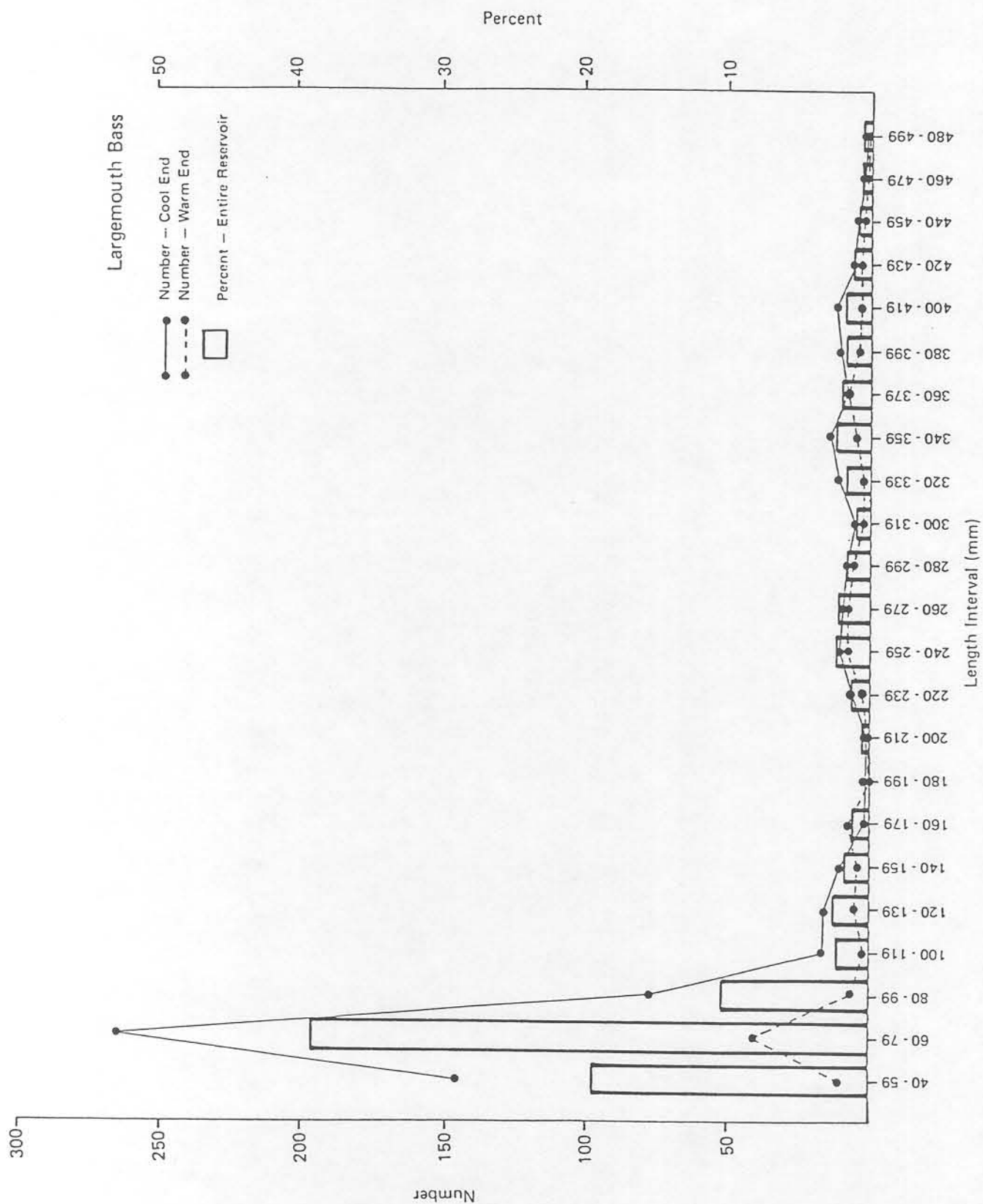


Figure 9. Length frequency distributions of Largemouth bass collected during a rotenone survey of Newton Lake, September 1983.

Bluegill

In contrast to the excellent sport fishing opportunities that appear to be available in Newton Lake for channel catfish and largemouth bass, the fishery for bluegill appears to be limited because of stunting in the population. YOY bluegill (<60 mm) constituted 48.5 percent of the catch, and 99.9 percent of the catch was <150 mm (6"), too small to be sought by most anglers. Moreover, no bluegills ≥ 160 mm were captured (Figure 10). Other investigators (ESE 1982, IDOC 1983, 1984) have also reported that few quality size bluegills are present in Newton Lake (see Section 3.1.4 for additional discussion of the size distribution of bluegills in Newton Lake).

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